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ABSTRACT

The objective of this study was to develop an economic approach to the forecasting of allied health manpower in markets in the State of California. The health manpower categories considered included: (1) Medical technology, (2) occupational therapy, (3) dietetic and nutritional services, (4) physical therapy, (5) health administration, (6) environmental health, and (7) speech pathology and audiology. Four projection techniques were applied to the seven selected health-related fields. The first was a basic population ratio approach, the second a modified ratio approach that brings in a limited number of other factors affecting demand, the third an econometric approach that assumes equilibrium between supply and demand, and the fourth an econometric approach that assumes disequilibrium between supply and demand. A committee of economists from California State Universities and Colleges served in an advisory capacity to the project, and it was the consensus that the general approach used was methodologically sound. The study was limited to using existing sources of data, which differed in their completeness for the various fields. The forecasts developed are useful for curriculum planning, faculty staffing, and career development. An overriding theme resulting from the empirical work is that these allied health manpower markets are heterogeneous, i.e., variables significant in one market were found not to be significant in another. The most significant issue that became apparent was the need for data of high quality. While the basic and modified ratio approaches are easily programed for staff use, the general conclusion is that the econometric approach with markets in equilibrium is the most viable. The report includes summary of the literature review, lists of data needs, and future research suggestions. (WL)

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MANPOWER PROJECTIONS TO 1980

ECONOMETRIC STUDY

By

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and

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for

THE CALIFORNIA STATE UNIVERSITY AND COLLEGES

HEALTH MANPOWER EDUCATION PROJECT

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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PREFACE

The manpower projections contained in this document are the work of Drs. Theodore Tsukahara Jr. and Gordon A. Kubota, both econometricians who have had experience working with health manpower data. They have applied four projections techniques to seven selected health-related fields, the first a basic population ratio approach the second a modified ratio approach which brings in a limited number of other factors affecting demand, the third an econometric approach which assumes equilibrium between supply and demand, and the fourth an econometric approach which assumes disquilibrium between supply and demand.

A committee of economists from CSUC campuses served in an advisory capacity to the project and although there were professional differences of opinion, it was the consensus that the general approach used here was methodologically sound.

The study was limited to using existing sources of data, which differed in their completeness for the various fields. We attempted to calculate regional projections within the State of California, but this was not possible due to the lack of adequate existing data. Even at the state level some data were at best marginally adequate.

We hope that the results here will be of value, not only for the projections themselves, but the comparison of the merits of the four approaches and in highlighting the data gaps which must be remedied for future studies.

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REVIEW OF THE LITERATURE

This review of the literature considers work relevant to the projection of allied health manpower. While it is not meant to review general manpower studies, it does focus on economic methods for projecting the specified allied health manpower needs into the future. In addition, special attention is given to studies which pertain to California's allied health manpower problems.

The format of the literature review includes selected abstracts and a more general bibliography. Selection for inclusion in the abstract section depends heavily on the quantitative and empirical contribution of the study in question. Rather than attempting to exhaust the literature, this review focuses on major contributions which are theoretical or empirical in nature.

Acton, Jan and Robert Levine. STATE HEALTH MANPOWER PLANNING: A POLICY OVERVIEW. Rand, May, 1971.

The issue of allied health manpower is important to the planning of medical education programs. For such manpower to be utilized, appropriate programs must be designed, and the role and availability of allied health personnel be defined in order to assess the demand for physicians and other personnel.

Uncertainty, however, surrounds many of the allied health professions. New categories of health personnel, e.g. physician's assistants, raise questions about legal responsibilities, the technology and organization of health care delivery, and public acceptance of allied health manpower. This compounds the uncertainties planners encounter when predicting future "need" or "demand" for health care. Thus, flexibility in planning appears to be crucial. The authors, however, conclude:

1) Although precise demands are uncertain, the trend in the need for allied health personnel is upward. We can plan for substantial expansion of training facilities and programs without worrying too much at this time about the ultimate levels of need. Lead times both for training medical technologists and for setting up training programs are much lower than for physicians, so planning can be flexible and relatively short-term.

2) Interstate migration among trained medical technologists is substantially lower than among professionals, particularly physicians, so expanded training will pay off for the state. Increased federal funds will become available for this purpose.

3) The AMA sees the following trends in training allied health manpower:

   -The place of such programs on college campuses rather than in hospitals;
   -The rapid growth of such programs in proliferating community colleges;
   -The emergence of new colleges of allied health professionals;
   -The growth of core curricula to train together different categories of professionals and technicians who will later work as teams.

4) Low salary levels for health occupations appear to be a major deterrent to male interest in allied health positions, despite the annual flow of 20,000 to 30,000 military medical corpsmen into the civilian population.

The authors suggest that ordinary pay incentives would significantly attract partially trained veterans of military medical service.

5) State authorities, local hospitals, clinics, and physicians should signal local training facilities and counselors concerning their future needs.

6) The authors also propose the creation of scenarios of likely developments in health care over the next 5-10 years. The scenarios are subject to wide varieties of trainee sources, training programs, medical care technology, legal constraints, and levels of public acceptance. Explication of such scenarios may reveal many issues that will guide program planning and development. Ultimately, the decision-maker may use this method for detailed planning and development if he places a probability distribution over the likelihood of each scenario occurring and then chooses the program which yields the best expected outcome.

Auster, Richard, Irving Leveson, and Deborah Sarachek, "The Production of Health, An Exploratory Study," JOURNAL OF HUMAN RESOURCES, Vol. 4, no. 4 (Fall, 1969), pp. 411-436.

OBJECTIVE

To answer the question: "What is the contribution of medical services as opposed to environmental factors to changes in the health of the population?"

METHODOLOGY

The relationship of mortality of whites to both medical care and environmental variables is examined in a regression analysis across the states in 1960. Medical care is alternatively measured by expenditures and by the output of a Cobb-Douglas production function combining the services of physicians, paramedical personnel, capital, and drugs. Simultaneous equation bias resulting from the influence of factor supply curves and demand for medical care is dealt with by estimating a more complete model. Both two-stage least squares and ordinary least squares estimates are presented.

CONCLUSIONS

Three major conclusions are implied by the findings. First, a one percent increase in medical expenditures reduces death rates by 0.1 percent. Second, the effects of education on mortality are approximately double those of medical care. Third, there seems to be a positive relationship between income and mortality.

Barzel, Yoram, "Productivity and the Price of Medical Services," JOURNAL OF POLITICAL ECONOMY, Vol. 77, no. 6 (November/December, 1969), pp. 1014-27.

OBJECTIVE

To show that the price of medical services has not become relatively more expensive nor is the production of these services subject to a smaller productivity advance than other products and services in the economy.

METHODOLOGY

Formulating an underlying Lancaster utility function, the author argues that attention should be focused on the population's health level. The ideal way to approach this problem is to determine how much it would cost to maintain the consumer's health at a constant level at different points in time. A valid price index of medical services might be constructed by using insurance companies' expenses in each period. The author then constructs a hypothetical index.

CONCLUSION

The price of medical services has not increased to the extent indicated by the medical component of the CPI since productivity increases in the medical industry have been at least as fast as those of the rest of the economy.

Berry, Ralph E., "Returns to Scale in the Production of Hospital Services," HEALTH SERVICES RESEARCH, Vol. 2 (Summer, 1967), pp. 123-39.

OBJECTIVE

To investigate whether or not economies of scale exist in the production of hospital services.

METHODOLOGY

The subject is approached from a theoretical point of view including recent attempts to provide measurements. The major conclusion drawn is that hospitals do not produce homogeneous products and that this issue must be fundamentally addressed. The empirical analysis begins by grouping hospitals with identical facilities and services. Forty groups were reported on and simple regressions run with average cost as the dependent variable and total patient days as the independent variable. The primary source of data was from the American Hospital Association for 1963. Sample size equaled 5293.

CONCLUSIONS

The author argues that the data overwhelmingly support the conclusion that services are produced subject to economies of scale in the short-term general and other special hospital industries when relatively homogeneous products are considered.

Bureau of Planning, Pennsylvania Department of Education, A DESCRIPTION OF THE DEMAND AND SUPPLY OF ALLIED HEALTH PERSONNEL TRAINED BY INSTITUTIONS OF HIGHER EDUCATION IN THE COMMONWEALTH OF PENNSYLVANIA, (Harrisburg: Pennsylvania Department of Education, 1971).

OBJECTIVE

To generate knowledge related to the demand and supply of allied health occupational workers in Pennsylvania to help the Commonwealth and institutions of higher education plan college-level educational programs for the development of paraprofessional allied health personnel.

METHODOLOGY

Employing national level data, Commonwealth data, and survey response, the balance between supply and demand is considered. Two major assumptions are made: first, that Pennsylvania's annual growth ratio of the national population will continue to diminish; second, that the Commonwealth's demand for health personnel will parallel the national demand. With these assumptions, the demand side is tied to the national figures.

CONCLUSIONS

The major conclusion of this study is that the demand for allied health workers greatly exceeds the supply. Of special interest are the following projections:

PERCENT DEFICIT
by 1975

Dieticians and Nutritionalists	54%
Medical Technologists	52
Physical Therapists	1.4
Occupational Therapists	288
Speech Pathologists and Audiologists	-93

Comprehensive Health Planning Association of Imperial, Riverside and San Diego Counties, HEALTH MANPOWER FORECASTS AND TRENDS, 1975 - 1985, N.D.

OBJECTIVE

To project the demand in San Diego and Imperial Counties for thirty-one health manpower occupations for 1975, 1980 and 1985.

METHODOLOGY

Based on a model designed to reflect the activities of San Diego and Imperial counties, a data baseline is employed to project the 31 health manpower categories at five year intervals. Greatest weights are given economic inputs such as employment, income, inflation, service costs, etc. This model uses component weighting, correlations, and simple regressions of the data in order to make predictions.

CONCLUSIONS

Slow growth is expected in most occupations during the next five years. The high schools, community colleges, and universities are expected to keep pace with the numerical needs for health professionals without additional effort. Of special interest are the following predictions:

PERCENTAGE CHANGE

from 1972 base

	1975	1980	1985
Clinical Laboratory Technician	3.9	13.0	27.1
Dietician	38.3	108.2	191.7
Physical Therapist	3.1	19.3	42.6

Deane, Robert T. and John B. McFarland, "The Direct Estimation of Demand for Ancillary Personnel in Physicians' Practice," in AN ORGINAL COMPARATIVE ECONOMIC ANALYSIS OF GROUP PRACTICE AND SOLO FEE-FOR-SERVICE PRACTICE--FINAL REPORT, USC, prepared for National Center for Health Services Research (National Technical Information Service, U.S. Department of Commerce, January, 1974).

OBJECTIVE

An understanding of the individual factors which impact upon the demand for ancillaries will enable policy makers to increase aide utilization by altering the existing incentive structure. Therefore, the paper attempts to isolate key policy manipulatable determinants of ancillary demand.

METHOD

1. The study starts from the Cobb-Douglas production function:

$$Q = \alpha A^{\beta_1} D^{\beta_2} R^{\beta_3}$$

(where Q is the output, in total patient visits; A, the number of full-time equivalent aides employed by the practice; D, the number of full-time equivalent physicians working in the practice; and R, the number of rooms in the working environment.)

2. From this production function, several demand functions were derived under conditions of both cost-minimization and profit-maximization. Demand functions were estimated assuming the following objective functions:

a. Long-run, cost-minimization, all inputs endogenous
b. Short-run, cost-minimization, capital output exogenous
c. Long-run, profit-maximization, all inputs and outputs endogneous
d. Short-run, profit-maximization, capital input exogenous
e. Short-run, profit-maximization, capital and physician input exogenous

3. The strictly dual factor demand specifications under alternative objective functions were relaxed by adding more information into the total ancillary demand equation. The new terms included:

a. The ratio of office visits - this ratio should be positively related to aides per physician because office visits typically involve more intensive use of aides than other types of visits.

b. The elective task delegation index - this represents an attempt to measure differences in propensities to delegate tasks traditionally performed by physicians.

c. The mean weekly hours of full-time physicians in practice - as full-time hours increase the use of ancillary personnel should also increase.

d. The physician-population ratio in the county of practice.

4. The authors attempt, by using total malpractice insurance costs as a proxy, to include the threat of malpractice as a factor affecting demand for ancillary personnel. However, almost no correlation existed between this proxy and aide utilization. Therefore, if the threat is present, it is reflected in a reduced level of delegation rather than as a separate item. Attempts to include the proportion of low income patients treated by each practice and to distinguish utilization differences by specialty yielded poor results.

5. There are wide variations among aides as to skill level and task assignment, thus warranting examination of demand for subgroups of workers. The authors felt it important to modify and expand the specification beyond the strictly derived functions.

a. The "best" strictly derived demand function was chosen as the point of departure. For each aide grouping, this was the short-run, profit-maximizing, single factor optimizing equation.

b. As in the total ancillaries case, the demand function was expanded to include additional variables and all factor outputs were converted to a per physician basis.

CONCLUSIONS

1. The major conclusion of the study is that factor demand studies will probably have to use extensions of strict duality conditions in order to increase the policy significance of the results. This flexibility in specification becomes almost imperative as the factors are more finely disaggregated.

2. The "best" equations were consistently those derived by assuming a short-run, profit-maximization, other inputs exogenous objective function.

3. Four significant influences - number of rooms, number of full-time equivalent physicians working in the practice, number of mean weekly hours of full-time physicians in practice, and the elective task delegation index - were isolated in the equation for total ancillaries. Fewer significant influences were identifiable for the disaggregated demand function.

4. The capital measures of total rooms per physician for total ancillaries, and special room types per physician for the groupings of ancillaries, indicate that if the rooms are available, physicians don't hesitate to make use of them by employing more ancillaries.

5. As size of practice grows, total ancillaries increase more than proportionately, but this does not hold categorically for each group of ancillaries. Thus, results based on estimates for total ancillaries should be used cautiously.

6. As the physician lengthens his work week, the demand for total ancillaries increases, but weekly physician hours significantly influence only the demand for nursing personnel.

7. Those physicians practicing in areas with low physician-population ratios ("scarcity" areas) tend to employ more ancillaries.

8. The elective task delegation index was significant in the total ancillary demand equation. But, when applied to individual ancillary groupings, it was consistently insignificant. This result was unexpected, especially in reference to nursing personnel who can, and do, substitute for physicians in a variety of tasks.

9. To the authors' surprise, the ratio of office visits to total visits failed to enter any of the demand equations significantly.

Division of Manpower Intelligence, Bureau of Health Resources Development, THE SUPPLY OF HEALTH MANPOWER, 1970. PROFILES AND PROJECTIONS TO 1990, U.S. Department of Health, Education, and Welfare, February, 1974.

OBJECTIVE

This study is an effort to provide information and analysis that could be used in developing alternative strategies for the education of health manpower. This overall effort, termed Project SOAR (Supply, Output, and Requirements), is viewed as an integrating and synthesizing analysis.

METHODOLOGY

The supply projections developed are admittedly related to the future profiles of supply, independent of any considerations of demand. In general, the basic methodological approach is to estimate active supply, develop graduate additions, account for separations from the labor force, relate population relationships, and to develop specialty projections for medicine. This methodology is basically a highly sophisticated version of a ratio analysis with some accounting procedures.

CONCLUSIONS

While numerous projections of health manpower are made for the various skill categories, the following are especially of interest.

	NUMBER of ACTIVE FORMALLY TRAINED PERSONNEL			PERCENT CHANGE	
OCCUPATION	1970	1980	1990	1970-80	1980-90
Dieticians	15300	18170	22340	18.8	23.0
Medical Technologists	45000	80620	123520	29.2	53.3
Occupational Therapists	7300	11760	16880	61.1	43.6
Physical Therapists	11550	23030	36570	99.4	58.8
Speech Pathologists and Audiologists	13300	37070	70930	178.8	91.4

Ehrenberg, Ronald G., "Organizational Control and the Economic Efficiency of Hospitals: The Production of Nursing Services," JOURNAL OF HUMAN RESOURCES, Vol. 9, no. 1 (Winter, 1974), pp. 21-32.

OBJECTIVE

To estimate the degree to which hospitals substitute across different categories of nurses as their relative wages change and to determine whether the degree of substitution is related either to the type of organization controlling a hospital or to the size of a hospital.

METHODOLOGY

The author specificies a single equation in which the dependent variable is the ratio of RN employment levels to licensed practical nurses' employment levels. Predetermined variables include a dummy variable for the proportion of admissions for general medical and surgical cases, the wage ratio, revenue per bed, annual number of short-term inpatient days, annual number of long-term inpatient days, and annual number of outpatient visits. The model is estimated with ordinary least squares in a logarithmic formulation for each organizational control category of hospital. The data employed comes from the 1969 AMERICAN HOSPITAL ASSOCIATION ANNUAL SURVEY.

CONCLUSIONS

The results support the view that private for-profit and nonprofit hospitals tend to substitute licensed practical nurses for registered nurses as their relative wages change. However, such substitution does not occur uniformly across different classes of hospitals. In addition, nursing employment levels in publicly operated hospitals seem to be insensitive to the wages of different categories of nurses.

Ernst and Ernst, HARTFORD HOSPITAL STUDY OF THE COST OF EDUCATION PROGRAMS (Hartford: Hartford Hospital, 1972).

OBJECTIVE

To distinguish and determine the net cost effect of educational programs upon the total cost of operating Hartford Hospital assuming that, if the educational programs were discontinued, the Hospital would maintain the same level of patient care and service to the community.

METHODOLOGY

Basically an accounting approach is used, although a survey instrument and a series of interviews were employed.

CONCLUSIONS

The net theoretical increase in the total operating cost to Hartford Hospital would have been $9,088 had all educational programs been discontinued before the beginning of the fiscal year.

Feldstein, Martin S., "An Econometric Model of the Medicare System," QUARTERLY JOURNAL OF ECONOMICS, Vol. 85, no. 1 (February, 1971), pp. 1-20.

OBJECTIVE

This paper explores the reasons for and implications of interstate variations in the quantities of health services used. In addition, the model and related equations are used to test the effectiveness of various specific features of the Medicare program and the use of supplementary medical insurances.

METHODOLOGY

An econometric model is specified with five endogenous variables: the proportion of enrollees with supplementary medical insurance; the hospital and extended care admission rates/1000 enrollees, and the average levels of hospital and medical insurance benefits. The predetermined variables include: demographic characteristics of enrollees, population density, average income in the state, health policy variables, and characteristics of the local health care system. All equations of the model were specified to be linear in the logarithms of the original variables. The model was estimated using instrumental variables with a sample of data from 47 states.

CONCLUSIONS

The econometric model explains a substantial portion of the variation in the quantity of health services used. These variations may be explained by the exogenous variables employed. In addition, the amount of hospital care received by Medicare patients is substantially less sensitive than the nonaged population to interstate differences in the availability of hospital beds, indicating that a higher proportion of hospital care goes to the aged in those states in which facilities are relatively more scarce. Further, uniform comprehensive insurance for the aged is not an appropriate policy when states differ in the availability of resources and the pattern of competing demands.

Fuchs, Victor R., and Marcia J. Kramer, DETERMINANTS OF EXPENDITURES FOR PHYSICIANS' SERVICES IN THE UNITED STATES, Occasional Paper 117, National Bureau of Economic Research, December, 1972.

OBJECTIVE

First, to provide a statistical decomposition of the growth of per capita expenditures for physician services at the national level; second, to develop and test a formal model to analyze the behavior of physicians and patients.

METHODOLOGY

In order to accomplish the first task, the authors examine the rate of change in expenditures and related variables over the period 1948-68 and for subperiods 1948-56, 1956-66, and 1966-68. The growth rate for any period is calculated by treating the variable under study as a logarithmic function of time and fitting a least-squares regression through all the annual observations. Various sources of data are employed.

In order to accomplish the second task, the authors specify a model for physicians' services within which a broad range of hypotheses regarding the behavior of patients and physicians can be investigated. The simultaneous equations structure has a behavioral equation dealing with variations in demand, number of physicians, physician's productivity, and the amount of insurance coverage. Each of the structural equations is estimated with two stage least-squares. Data employed come from a variety of sources.

CONCLUSIONS

The most striking finding of this study is that the supply factors (i.e., technology and number of physicians) appear to be the most important in determining the utilization of and expenditures for physicians' services.

Goldfarb, Marsha G., "A Critique of the Health Manpower Planning Literature," Working Paper Series no. 73-2, Office of Regional Activities and Continuing Education, Yale University School of Medicine, 1973.

OBJECTIVE

To evaluate the feasibility of developing an econometric model to simulate the health care delivery system of the South Central Connecticut region, permitting sophisticated forecasts of probable future demands and supplies of health manpower, and enabling policy makers to prevent predicted shortages.

METHODOLOGY

The author considers both non-stochastic manpower models and simultaneous equation econometric models. The particular non-stochastic manpower models considered are categorized as (1) fixed population ratio methods; (2) professional standards approach; (3) job vacancy approach; and (4) optimizing models, such as linear programming. The simultaneous econometric models considered are the Feldstein-Kielman Model and the Yet-Intriligator-Kimbell-Drabek model.

CONCLUSIONS

The author concludes that the fixed-coefficient manpower planning models and multivariate regression models are inadequate references for formulating a manpower planning model for the New Haven region. In addition, comprehensive econometric simulation models are even more difficult to develop, making them less feasible at this time.

Greenfield, Harry I. ALLIED HEALTH MANPOWER: TRENDS AND PROSPECTS (New York: Columbia University Press, 1969).

INCREASED NUMBERS OF ALLIED HEALTH PERSONNEL

Based on census data, Greenfield notes a significant increase between 1950 and 1960 in allied health manpower. His purpose is to examine the structure of the allied health labor market and to note trends in the demand and supply for allied health personnel.

It is plausible to argue that the employment of sub-, non-, or para-professional personnel is ipso facto a measure of shortage. Until the pressure of demand on independent professionals is extreme, technicians are not likely to be utilized. In fact, legislation, framed largely by professional organizations, prevents persons of less skill from performing certain functions which are in the domain of professionals. The income incentive which is inherent in a fee-for-service arrangement operates to inhibit the loss of income-producing services. It is only when the demand is so great as to outweigh the loss of services that professionals accede to the technicians performance of certain functions first on a de facto then a de jure basis. In the case of medical care, progressively more functions previously considered a monopoly of the physician are being performed by technicians: the nurse, the laboratory technician, the X-ray technician, the therapist, etc.

Modifications in manpower training, together with changes in the production process for health services, plus newer concepts in the treatment of disease (i.e., the health team approach) have combined to increase the numbers of non-core, or allied health personnel, at a much greater rate than the core.

CLASSIFICATION OF HEALTH MANPOWER

Greenfield examines several taxonomic frameworks which help to gauge the impact of economic changes on health manpower; to provide information for occupational guidance; and, to guide the education and training of manpower. Using the level of required education as a criterion, Greenfield creates the following categories:

-allied health professionals: minimum of a bachelor's degree
-allied health technicians: vocational school training
-allied health assistants: various educational levels up to and including high school graduation

A functional classification system of health manpower may be more useful in relating changes in demand for health services,

in technology, in concepts of disease management, and in general demographic characteristics to health manpower requirements.

Jeffrey Weiss ("The Changing Job Structure of Health Manpower," unpublished dissertation, Harvard University, 1966.)

Weiss groups occupations into job families (patient care, technical and laboratory services, administration and planning, etc.) according to two criteria: major technical focus and level of job content. This functional classification avoids pejorative connotations of older nomenclature. Weiss concludes that in health, the level of job content has declined in that low job-content levels have gained relative to those with high and middle levels.

An important analytic proposition behind Weiss's job structure analysis is that the output of health services should be viewed in terms of joint inputs, and further, that there is a greater degree of substitutability among the input factors than has heretofore been acknowledged. Weiss, however, fails to recognize legal or institutional barriers that exist throughout medical manpower, which severely limit the possibility of substitution. This inflexibility decreases the efficiency of input factors. Moreover, the distinction between substitutes and complements must be made. Often, "lower-level" job-content occupations are complementary to rather than substitutes for "middle" and "high-level" occupations. Division of labor in health services as well as the introduction of new techniques have created lower-level occupations, which are not necessarily substitutes for existing jobs. (The nuclear medical technologist, for example, is not a substitute for an older occupation.) Also, Weiss's system emphasizes intra-industry substitutions, but many problems of health industry (especially with respect to recruitment) have their roots in inter-industry mobility.

AN ALTERNATE FUNCTIONAL CLASSIFICATION

An alternate classification of allied health manpower focuses on the major functions of health services - the types of services consumers demand and physicians provide. Occupations may be classified in the following categories: diagnostic, therapeutic, patient maintenance, rehabilitative and supportive, and administrative.

Although functional plurality may cause some difficulties in classification, several advantages characterize a functional approach:

- Personnel requirements can be easily derived from changes in the demand for various types of health services
- Functional grouping should facilitate more meaningful cost estimates both within and outside of hospital settings

-Functional classification can add the needed dimension of relevance to studies of wage levels, skill requirements, and wage differentials.

FACTORS AFFECTING THE DEMAND FOR ALLIED HEALTH PERSONNEL

The following contribute to an increased demand for allied health personnel:

1. Increased demand for care: a major thesis of the book is that the strong and persistent increase in employment of all types of health manpower, especially at the non-core levels, arises basically from increases in the aggregate effective demand for health services, with changing technology playing an important but subordinate role.

2. Increased knowledge, which requires additional technicians and laboratory personnel.

3. Rising costs of medical goods and services have generated a concern over the efficient use of manpower. Occupational tasks have been subdivided and less costly labor substituted for more costly labor.

4. Changing locus of employment: nursing homes and other institutional settings, characteristically with higher percentages of allied health personnel, have assumed greater roles in health care delivery.

5. Changing concept of disease management: "progressive patient care," or the concept of illness as a continuum ranging from critical to recovered, necessitates finer division of labor and of facilities.

6. Changing patterns of health care financing have altered hospital and physician utilization patterns.

Two countervailing forces are:

1. Technological development (e.g., computers) may replace labor in performing tasks.

2. Increased tendency of hospitals to contract-out in areas such as general maintenance, payroll processing, etc. (although the employees in these service firms are not classified as medical personnel).

FACTORS AFFECTING THE SUPPLY OF ALLIED HEALTH PERSONNEL

To predict the supply of allied health personnel, project population and use the current rates of entry into health care. In

forecasting, an attempt to incorporate changing trends - i.e., extension of schooling period for certain age groups, trends toward lowered age of marriage, etc. - should be made.

EDUCATION AND TRAINING

Educational prerequisites (high school graduation or approved training program completion) may limit the supply of potential workers. A variety of educational requirements has arisen as technology and organizational changes accelerate the division of labor and generate jobs on all skill levels.

The absence of exact measures of how much education is "needed" to do various jobs creates a problem insofar as professional societies continually increase educational requirements, and therefore limit the supply of workers. In addition, little information on the quality of instruction of health subjects is available.

An integrated training program which enables vertical and horizontal mobility of health workers is also lacking. Instead, each new occupation has its own training program, thus creating rigid barriers to job entry. The hospital has come to be seen as a repository of dead-end occupations and faces difficulties in manpower recruitment.

Given the high turnover rates and the rapid expansion of the health fields, hospital administrators have found it necessary to utilize their work force under conditions of limited education, limited training, limited skill transferability, and tight supervision. This provides workers for specific jobs in specific hospitals, but not meaningful lifetime careers which would be attractive to well-trained men beginning their working lives.

LARGE FEMALE COMPONENT

The predominance of females in allied health fields has a significant impact on the supply of workers. Women tend to have a higher dropout rate because they leave the work force to marry and to start families. Significant numbers of middle-aged women, however, do return to work and are an important source of manpower. But resources are often consumed in retraining this pool of workers.

ALLIED HEALTH LABOR MARKETS

Greenfield notes that a variety of institutional constraints influence the allied health labor market. Often bound by legal and extra-legal restrictions, the health labor market may be described as one of noncompeting groups of workers and, in some

instances, the situation approaches that of a closed shop where membership in a professional association must precede employment.

Furthermore, allied health labor markets deviate from classical competitive labor market models in several significant respects: hospitals, the major institutional employers, are largely in the not-for-profit sector; females comprise a large percentage of the labor force; and, volunteers perform a significant portion of the work. The need to function 24 hours a day also creates unique features such as "on call" pay for personnel, staff physicians, etc., to ensure efficient use of manpower. Greenfield contends that hospitals are monopsonists because of the occupation-specific nature of most allied health jobs. Workers face few alternative employment possibilities.

While the hospital currently retains its position as key bargainer and pattern setter in the employment and earnings of workers in the health services industry, structural changes in health care delivery which expand the role of community health facilities will weaken the hospital's dominance. Perhaps, eventually, the hospital may find itself in the position of a price (wage) taker rather than that of a price (wage) maker.

Greenfield examined wage trends in the non-agricultural and the hospital sectors to help judge whether the demand for allied health services has increased at a greater rate than the supply of workers. In addition, he considers signs of classic techniques (as discussed by Richard Lester, "Adjustments to Labor Shortages," Princeton University, Department of Economics and Sociology, Industrial Relations Section, 1955) employers use to adjust to labor shortages - changes in recruitment methods; lower quality standards for new employees; special increases in starting rates, maintenance rates, or hiring of new employees above starting rates or into higher than normal job classes; changes in production methods; and substitution of male for predominately female workers.

Census data for 1950 and 1960 were used to study the changes in non-agricultural employment, and in the employment of basic hospital personnel for 15 major standard metropolitan statistical areas (SMSA). An index of hospital manpower endowment, the ratio of population to hospital personnel, was also calculated. The results showed increases in hospital personnel employment in excess of increases in non-agricultural employment over the decade of the 1950's. There also appeared to be great inter-area variation in hospital manpower endowment.

Racial barriers appeared to have been easier to overcome than those related to sex. This implies that either strong taboos persisted with respect to male employment or that wage rates were still too low to attract males, especially those with family responsibility.

Geographic wage differences for the same or similar occupations may be ascribed to several factors: differences in living costs; the presence or absence of unions and the degree of unionization; different supply-demand relationships; and different laws. In health occupations, Greenfield suggests that unions and legislation are of minimal influence, that differences in living costs among metropolitan areas are small, and that, therefore, different supply-demand relationships are the major determinants of area wage differentials.

Greenfield then attempts to formulate judgments regarding the supply and demand for labor in different geographical areas and to determine whether wages in health areas conform to general wage pressures. Areas were ranked by average earnings in manufacturing and in several health occupations for 1960. This study revealed a high degree of consistency between areas which ranked high in manufacturer's earnings and those high in medical earnings.

Using data from the Bureau of Labor Statistics (Earnings and Supplementary Benefits in Hospitals for the decade 1956-1966), the author concludes:

-All of the medical occupations shown recorded wage increases in excess of those in manufacturing.

-There is sound presumptive evidence of rather strong nation-wide demand for occupations which recorded wage increases exceeding those in manufacturing in all SMSAs.

-Since the same areas did not appear on the shortfall list (i.e., increases below those in manufacturing) for all occupations, the shortfall list served as a surrogate index of the relative manpower endowment in the various regions.

-Occupations which are in extremely short supply can be identified by focusing on the wage increases, which, at a minimum, were twice as great as those in manufacturing.

Inter-area and intra-area changes were examined in terms of absolute wage levels and of interoccupational wage differentials. The purpose was to examine how changes in the occupational and regional distribution of medical manpower may have been responsive to and affected by wage pressures. An important question in this respect is whether regional wage variations for the same occupation are becoming more uniform or more dispersed over time. If the former is true then it might be assumed that medical personnel are becoming more evenly distributed among the regions; and if the latter, that the distribution is less even - a fact which may be indicative of a drawing-off of personnel from the lower to the higher wage area. Percentage

wage differentials between regions for a given occupation revealed that in the vast majority of cases, the wage differences between one region and the next lower one were less than 5 percent in order of magnitude. Two hypotheses which may explain narrow inter-area differentials in a given occupation are that the distribution of personnel is fairly uniform and that some professional organization has succeeded in establishing national norms for its members. On the other hand, wider wage differentials may be indicative of shortages of specific occupations in some areas or they may be due to some special activities such as successful unionization drives or legislation which affect the area wage structure.

By arranging the data within one area in descending order, from the most highly paid to the least paid of the major medical occupations in the BLS survey, one can see where a particular occupation stands in the wage hierarchy. By inter-temporal analysis (Greenfield looks at changes over the decade 1956-1966), one can determine which occupations in the area gained and which lost in relative position in the wage structure. An increase in the relative rank of an occupation is presumed to indicate a relative shortage, and a decrease in relative rank indicative of a relative surplus. Relative rank increases for the following occupations occurred in many areas: head nurse, general duty nurse, female medical technician, medical social worker, dietician, and physical therapist. Decreases in relative rank were pronounced for both male and female X-ray technician, and medical record librarian. (It is important to emphasize that "unchanged" does not mean that the demand had not increased or that wages have not increased. The relative changes in wage hierarchy is what is of interest. Neither does the analysis reveal the extent to which employees of a given job family are actually doing the work of those whose titles, at least, place them on higher rungs.)

Using census data, Greenfield calculated unemployment rates for a variety of health occupations by subtracting those employed from the experienced civilian labor force and dividing that number by the experienced civilian labor force once again. This procedure was done for both 1950 and 1960. On the whole, unemployment rates in the medical occupations are much lower than they are in the economy at large. Indeed, zero rates and rates below one percent appeared frequently, indicating a situation of virtual overemployment - one in which there is not enough flexibility to allow for job changing. Finally, it should be observed that only in the occupations requiring little training were relatively high unemployment rates frequently seen.

CONCLUSIONS

Thus, Greenfield concludes that the medical labor market appears to have adjusted by classic means to the relatively

tight supply-demand situation since 1950. He goes on to suggest that the needs (effective demands) for medical and especially for allied health personnel will continue to grow rapidly, and although wages will also continue to rise, the rate of increase is a matter of conjecture. Greenfield notes a need to expand the medical labor force by inducing experienced workers to return to work and by training new workers for health jobs.

Furthermore, when studying the numbers of health workers, Greenfield cautions against ignoring the quality dimension. Quality depends not only on the training and capacities of the individual worker, but on how he is utilized with other workers and with physical inputs to produce the health care product. In short, overall efficiency is of prime importance.

Held, Phillip J., "Rural-Urban Differentials in Access to Medical Care: Some Preliminary Results," a paper presented at the Western Economic Association Conference, June, 1975.

OBJECTIVE

To measure the access to medical care from the supply side in urban and rural areas of the United States.

METHODOLOGY

The basis of this study is a survey of a sample of general and family practitioners, internists, and pediatricians. The sample is drawn from the 100 largest SMSAs, 56 randomly drawn smaller SMSAs, and a random sample of non-metropolitan sampling units. Means and standard errors are reported on the major physician categories.

CONCLUSIONS

Access to medical care does not appear to differ between rural areas and metropolitan areas when measured from the supply side. However, rural physicians see more patients, employ more aides, and work longer hours than their urban counterparts.

Intriligator, Michael, "A Note on the Perceived Substitutability of Allied Health Personnel for Selected Tasks in Physicians' Practice," in AN ORIGINAL COMPARATIVE ECONOMIC ANALYSIS OF GROUP PRACTICE AND SOLO FEE-FOR-SERVICE PRACTICE - FINAL REPORT, USC, prepared for National Center for Health Services Research (National Technical Information Service, U.S. Department of Commerce, January, 1974).

OBJECTIVE

To develop an index which measures the extent to which physicians believe one type of allied health personnel can be substituted for another type in the provision of health services. Such knowledge is useful in helping to understand physicians' decisions regarding the employment and utilization of such personnel. This knowledge may also be useful in indicating which training programs may be most effective in providing personnel for physicians' offices.

METHOD

1. The index is based upon responses to the AMA's 7th Periodic Survey of Physicians.

2. The tasks considered are: history taking, blood pressure, well-child examination, cast application or removal, minor sutures. The allied health personnel included are: registered nurses, licensed practical nurses, nurse aides, X-ray technicians, medical technicians, and secretaries.

3. The respondents provided information on the type of allied health personnel most likely to perform the task. The frequency with which aide type i and aide type j are cited as most likely to perform a given task depends, in part, upon the technical substitutability of these inputs. The aide types are good substitutes in the performance of the task if approximately the same number of physicians report each aide as most likely to perform a particular task.

4. A general index of perceived substitutability of any two ancillary personnel categories can be constructed by suitably aggregating responses over all to tasks included in the survey.

CONCLUSIONS

The study constructed an index of perceived substitutability among aide types, estimated the index using the AMA 7th Periodic Survey of Physicians, and reached the conclusion that physicians perceive nurse aides and medical technicians as the most substitutable, while X-ray technicians are the least substitutable type of allied health personnel. Medical technicians appear to be able to perform both laboratory and to some extent clinical tasks.

Intriligator, Michael and Barbara Kehrer, "An Econometric Analysis of Employment and Utilization of Allied Health Personnel in Solo and Group Practices," in AN ORIGINAL COMPARATIVE ECONOMIC ANALYSIS OF GROUP PRACTICE AND SOLO FEE-FOR-SERVICE — FINAL REPORT. USC, prepared for National Center for Health Services Research (National Technical Information Service, U.S. Department of Commerce, January, 1974).

OBJECTIVE

To analyze demands for allied health personnel in order to identify which factors represent significant influences on the employment and utilization of such personnel; and to compare the employment and utilization of allied health personnel, specifically nurses, technicians, and secretaries employed in physicians' offices.

METHOD

1. A simultaneous-equations model is developed to take account of the interrelationships among the demands for the three categories of allied health personnel and the delegation of tasks to these aides.

2. The model contains four endogenous model variables - the number of nursing personnel per physician, the number of technical personnel per physician, the number of secretarial personnel per physician, and the propensity to delegate tasks to allied health personnel (constructed from data on the percentage of times physicians delegate each of the ten health service tasks to allied health personnel).

3. The assumption that wages are determined exogenously reflects the institutional character of medical practices.

4. Capital stock (examining rooms for nursing personnel, lab and X-ray facilities, waiting rooms and administrative offices) are assumed fixed in the short-run when the number of allied health personnel may be varied.

5. The first three equations of the model determine the employment of each category of allied health personnel as a function of the degree of delegation, all wage indices, the relevant capital stock, and the number of visits.

   a. An increase in the propensity to delegate is expected to increase the demand for all three types of allied health personnel, ceteris paribus.

   b. In all three equations, an increase in own wages is expected to decrease demand while an increase in wages of other types of ancillaries may increase or decrease

demand, depending on whether the two types of ancillaries are substitutes or complements, respectively.

c. Capital stock specific to each type of allied health personnel is expected to be a complementary factor of production.

6. The fourth equation of the model relates the propensity to delegate health service tasks to allied health personnel per physician in the practice.

a. Presumably, the more nursing, technician, or secretarial personnel available to practice, the greater the propensity to delegate.

b. The equation includes variables on the percentage of low and middle income patients to determine the effect of patient income on the degree of delegation.

7. Estimates of the model are obtained using data collected in the 7th Periodic Survey of Physicians and Survey of Medical Groups (AMA, 1971). Two-stage least squares estimates are presented for general practice and internal medicine for solo and group practices and also for comprehensive multispecialty (diversified) group practices.

8. Short-run demand elasticities are measured at the mean for the three categories of allied health personnel in each specialty and type of practice, with respect to both wages and visit-rooms (simultaneously changing visits and rooms).

CONCLUSIONS

1. In some categories, and for certain allied health personnel, wages are a significant influence (e.g., technicians in solo practice). In other categories rooms are a significant influence (e.g., solo internal medicine and diversified group practices).

2. In general, propensity to delegate is not a significant influence on ancillary personnel employment.

3. Visits per physician are an important influence on employment of allied health personnel per physician in solo general paractice and group diversified practice. If both visits and room change, however, it appears that only in solo internal medicine would there be an appreciable change in allied health personnel per physician. There would be a small change in solo general practice and diversified group practices, but no change in single specialty groups. In general, diversified group practices respond similarly to solo practices, while

single specialty groups respond less to changes in exogenous variables. These important differences between specialties and types of practice should be of interest both to economists concerned with markets for allied health manpower and to health planners concerned with influencing the organization of health services delivery in physicians' offices.

Intriligator, Michael, Richard Odem, Marianne Miller, and Herbert Schwartz. "Allied Health Personnel Hiring Sequence," in AN ORIGINAL COMPARATIVE ECONOMIC ANALYSIS OF GROUP PRACTICE AND SOLO FEE-FOR-SERVICE PRACTICE - FINAL REPORT, USC, prepared for National Center for Health Services Research (National Technical Information Service, U.S. Department of Commerce, January, 1974).

OBJECTIVE

To describe the hiring sequence of allied health personnel in solo physicians' offices and to examine how it varies among different medical specialties.

The hiring sequence is important for several reasons. First, it indicates the physician's decision with respect to the order of hiring personnel and thus, reflects the physician's subjective evaluation of the relative benefit and cost of various types of allied health personnel. Second, the hiring sequence could be important in studying the markets for the various allied health personnel. Third, it may indicate which policies might be most successful in encouraging physicians to increase output via more extensive utilization of allied health personnel.

METHODOLOGY

1. The data used in this paper were collected in the 7th Periodic Survey of Physicians conducted by the AMA in 1971. The survey, specifically designed to evaluate the economic aspects of alternative forms of medical practice and the utilization of allied health personnel in these practices, provided data on full-time equivalent employment of different types of allied health personnel: registered nurses, licensed practical nurses, nurse aides, laboratory technicians and assistants, X-ray technicians, medical technicians, pharmacists, secretaries, receptionists, bookkeepers, etc.

2. These types of employees were aggregated into three major personnel categories: nurses, technicians, and secretaries.

3. Recognizing that ancillary employment patterns may vary by specialty according to the nature of the specialty output and production processes, the sample is stratified by specialty Separate sets of probabilities are presented for solo and general practice physicians, medical specialties, and surgical specialties.

4. Conditional probability (the probability of hiring a particular type of aide, given various combinations of these

personnel), is used to describe the hiring sequence of allied health personnel. The probabilities also describe hiring practices - e.g., given that the practice employs a technician and a secretary, what is the technician-secretary? The study presents estimates of these probabilities obtained from cross-section data on aide employment patterns.

CONCLUSIONS

1. It is highly probable for one-aide practices to hire a secretary as the only aide, and for practices with two aides to hire a secretary and a nurse. In two-aide practices, a secretary is most likely to be hired before a nurse. Three-aide practices are most likely to hire a secretary as the first aide, a nurse second, and another secretary third.

2. For all solo practice physicians as well as for each of the three special classes examined, the probabilities that a given aide type be hired at a particular point in a sequence show that the probability of hiring a secretary decreases as the number of aides employed increases. The probability of hiring a nurse increases initially but decreases after the second aide. The probability of hiring a technician, on the other hand, increases as more aides are hired by a medical practice. Thus, if medical practices are encouraged to increase their output by hiring additional aides, it is likely that the increase in demand for technical aides will be relatively greater than the increase in demand for either nurses or secretaries.

Kehrer, Barbara and Michael Intriligator, "Malpractice and the Employment of Allied Health Personnel," in AN ORIGINAL COMPARATIVE ECONOMIC ANALYSIS OF GROUP PRACTICE AND SOLO FEE-FOR-SERVICE PRACTICE - FINAL REPORT, USC, prepared for National Center of Health Services Research (National Technical Information Service, U.S. Department of Commerce, January, 1974).

OBJECTIVE

To determine the extent to which malpractice insurance expenses constitute a real obstacle to greater use of aides in physicians' offices.

METHOD

The paper reviews literature on malpractice and the utilization of allied health personnel and data from the AMA's 7th Periodic Survey of Physicians.

CONCLUSIONS

The data shows that malpractice insurance expenses vary considerably across census divisions, by specialty, and between solo and group practice physicians, but vary within only a narrow range depending on the number of health personnel employed per physician. It may be concluded, therefore, that malpractice insurance expense per se is probably not a significant factor in influencing physicians' decisions to hire allied health personnel. It should, however, be noted that while malpractice insurance expense may not influence employment of allied health personnel, other aspects, in particular, nonpecuniary aspects of the role of malpractice, may still be an important influence on such employment.

Kehrer, Barbara and Michael Intriligator, "Tax Delegation in Physician Office Practice," in AN ORIGINAL COMPARATIVE ECONOMIC ANALYSIS OF GROUP PRACTICE AND SOLO FEE-FOR-SERVICE PRACTICE-FINAL REPORT, USC, prepared for National Center for Health Services Research (National Technical Information Service, U.S. Department of Commerce, January, 1974).

OBJECTIVE

Delegation of tasks tends to increase both the productivity of the medical practitioner and the quantity of output of medical services, provided that physicians do not reduce their own work load significantly upon increased employment of aides.

In order to construct a measure of total physician time saved by delegation of tasks, it would be important to know the specific tasks delegated, the amount of time it takes the physician to perform those tasks, and the frequency with which those tasks are performed in the practice during a given time period. Additionally, it would be desirable to consider and measure the amount of physician time saved by partial delegation, the transfer of a portion of a task from physician to aide. The study utilized descriptive statistics on task delegation to allied health personnel in physicians' offices derived from data obtained in the 7th Periodic Survey of Physicians conducted by the AMA in 1971.

METHOD

1. The AMA survey questionnaire asked physicians to report for each of the ten tasks:

   a. the "percent of time this task is performed by allied health personnel"

   b. the "type of allied health personnel most likely to perform this task"

2. The tasks in the questionnaire were selected on the following criteria:

   a. frequent performance in many practices
   b. frequent delegation in some practices and performance by the physician in others

3. The medians for the percent of times the ten tasks are delegated to allied health personnel for seven specialty groups (general and family practice, internal medicine, pediatrics, obstetrics-gynecology, orthopedic surgery, ophthalmology, and radiology) were calculated.

4. The study also compared delegation between solo and group practices in five major specialties (general practice, internal medicine, pediatrics, obstetrics-gynecology, and general surgery) of three tasks - instruction of patients, blood pressure, and immunizations.

5. Delegation frequency for the five major specialties was also calculated with respect to region.

CONCLUSIONS

Among the more important findings are the greater propensity for delegation (1) of easily routinized tasks, as compared with activities requiring clinical judgments; (2) in group practices; (3) in the Western regions of the United States; and (4) to registered nurses, rather than to other types of allied health personnel. Future work will relate these descriptive findings to other information on practice and physician characteristics obtained in AMA surveys and to Census demographic data in order to identify those factors responsible for differences in delegation among specialties, types of practice, and regions.

Kimbell, Larry J. and Robert T. Deane, "Analysis of the Utilization of Ancillary Personnel Using Production Functions" in AN ORIGINAL COMPARATIVE ECONOMIC ANALYSIS OF GROUP PRACTICE AND SOLO FEE-FOR-SERVICE PRACTICE-FINAL REPORT, USC, prepared for National Center for Health Services Research (National Technical Information Service, U.S. Department of Commerce, January, 1974).

OBJECTIVE I

To determine whether aides are being under-utilized on the average. This study uses data from the 7th Periodic Survey of Physicians (AMA survey) to test these earlier results.

METHOD

1. In 1971, the AMA surveyed individual solo practitioners and medical groups regarding their use of aides. The data pertain to 1970 activities.

2. The following Cobb-Douglas total revenue function was estimated by Kimbell and Lorant (1973) and used for this analysis:

$$PQ = \alpha H^{\beta_1} D^{\beta_2} R^{\beta_3} A^{\beta_4} e^{u}$$

where PQ = gross revenues from medical practice
H = (average) number of hours worked by the full-time physician(s) in the practice during a most recent complete week
D = number of physicians in the practice (the number of full-time physicians, plus .30 times the number of part-time physicians)
R = number of waiting, examining, and other rooms used in the practice, a measure of capital input
A = number of full-time equivalent allied health personnel employed by the practice
β_i are corresponding elasticities with u as a random error term.

3. The short-run, profit-maximizing number of aides, A, with rooms, physicians, and physician hours exogenous, is determined by the condition that the marginal revenue product of aides equals the marginal factor cost of aides.

4. An estimated profit loss from non-optimal utilization is calculated.

a. The total revenue function was used to predict revenues for actual aides and for optimal aides, with other inputs held constant at observed values.

b. The authors calculated the difference in factor costs associated with non-optimal utilization.

CONCLUSIONS

The AMA sample data indicate that the mean number of aides per full-time equivalent physicians actually utilized was 2.29, whereas the mean optimal number of aides was 3.89. On the average, then, only about 58% of the number of aides that are required to maximize profits are being utilized. These results are very similar to those found in previous studies despite the use of a different data source and production function.

OBJECTIVE II

To examine the current economic incentives for physicians to optimally utilize auxiliaries and to determine the reasons for their apparent inefficiency.

METHOD

1. The authors calculated the before-tax income foregone per physician resulting from the estimated non-optimal utilization.

2. Direct salary costs were used to calculate the incremental factor cost of aides.

CONCLUSIONS

1. Over 54% of all the firms are estimated to lose less than $3,000 per physician and over 75% less than $6,000 per physician. Only 3.9% of the physician practices are estimated to be losing more than $10,000 through non-optimal employment of aides.

2. While the number of aides utilized per physician may be higher for groups, the deviation from optimal aide usage is greater (except in large groups with over 26 physicians) than for solo practice and the economic incentives, in terms of income foregone from non-optimization, are less.

3. In the calculations, all non-labor incremental costs associated with higher input and output levels as well as the potential psychic costs incurred by expanding the ancillary staff (i.e., managerial headaches, fear of service quality deterioration, etc.) were excluded. When these expenses are considered, however, the net income losses become so small that many practices are unlikely to recover them with sizeable increases in their existing staffs.

4. After considering all costs, the evidence supports the hypothesis that individual physician practices optimize factor proportions in accordance with an objective function of profit-maximization.

5. Any policy that reduces psychic costs to the physician would lead to increased utilization of ancillary personnel with a consequent increase in output. Implementing policies to reduce the threat of malpractice, to remove legal barriers to task delegation, to reduce the fear of service quality deterioration, etc., would give the physician a positive incentive to increase aide utilization (and therefore output) to the new profit-maximizing level. There is every indication that he would respond to such an incentive. The impact of such policies, while not large on a per physician basis, could be quite large in total.

Kriesberg, Harriet M., John Wu, Edward D. Hollander, and Joan Bow, "Critical Review of Methodological Approaches Used to Determine Health Manpower Supply and Requirements," prepared for Health Resources Administration, DHEW by Robert R. Nathan Associates, Inc., April, 1975.

OBJECTIVE

To review the various methodological approaches used to determine health manpower supply and requirements where the requirements are defined as the manpower necessary to provide health services to a population.

METHODOLOGY

In reviewing the general methodological approaches to estimating manpower requirements, the authors consider: (1) the manpower/population ratio method; (2) the service target approach; (3) the health needs approach; (4) and the effective demand approach with four separate conceptualizations. In addition, the authors consider: (1) methodological approaches to estimating supply; and (2) uses and limitations of manpower statistics.

In producing a practical planning manual, the authors consider each methodological approach in terms of the problems addressed, the data required, the underlying assumptions, a step-by-step description, and an assessment of the strengths and weaknesses of each method.

CONCLUSIONS

The arguments presented yield some generalization. First, for the ratio methods, the major strengths lie in simplicity, minimal data requirements, low cost, and modest staff expertise. This method's major weaknesses include failure to account for future changes in socio-economic conditions, technological and biological advances and changes in the configuration of delivery systems.

Second, the strength of the service target approach is thought to be in its focus on the central issue of providing services, while the greatest danger of this method is the use of improper criteria for setting service standards.

Third, the strength of the health services needs approach is that manpower needs are determined by health care required. However, the most serious criticism of this approach is the method's failure to account for the patient's willingness to seek care and the community's ability to pay for health services.

Finally, the effective demand approach in its various forms is thought to have both strengths and weaknesses. Strengths include responsiveness to short-run changes, reliance on effective demand, utilization of dynamic changes, and ability to build upon strong data bases. Major weaknesses are identified as the inability to consider all demanders, the necessity for vast amounts of data and expertise for analysis, the necessity for very complex statistical analysis, and the inability to generally assess needs in local areas.

Lave, Judith R. and Lester B. Lave, "Hospital Cost Functions," AMERICAN ECONOMIC REVIEW, Vol. 60, no. 3 (June, 1970), pp. 379-395.

OBJECTIVE

To develop a method for estimating the hospital cost function which attempts to deal with the problems stemming from the multi-product nature of output.

METHODOLOGY

The authors formulate a cost function which allows Hicks-neutral technological change. The multi-product nature of the hospital is accounted for in two ways. The first procedure involves a two-stage analysis while the second procedure assumes that all hospitals have the same cost function. The data for the estimations are on 74 western Pennsylvania Hospitals for the period 1961-1967. In all, 14 semiannual observations were obtained for each hospital. Multiple linear regression is the basic tool of analysis.

CONCLUSIONS

There are three major conclusions drawn from the analysis. First, the marginal cost of a hospital bed is between 40 and 65 percent of average cost which indicates that the marginal cost is not a small percentage of average cost. Second, if economics of scale exist in the hospital industry, they are not very strong. Third, the rate of cost increase has been accelerating over time.

Lave, Judith, Lester Lave and Samuel Leinhardt; MEDICAL MANPOWER MODELS: NEED, DEMAND, AND SUPPLY, prepared for the State of California, Department of Health by Rand (Santa Monica, CA), March, 1974.

OBJECTIVE I

To examine alternative methods of forecasting physician manpower requirements.

(The authors distinguish between a populations's need for medical services, which are professionally defined standards, and consumer-determined demand for medical services.)

METHOD I: Normative Forecast Based on NEED

1. The classic Lee and Jones (1933) model consists of 4 steps:

   a. Determine the incidence of various illnesses in a population.

   b. Poll experts to determine the amount of services required to diagnose and treat each type of illness.

   c. Estimate the average number of services rendered per hour by a provider.

   d. Secure professional opinion on the average number of hours per year a provider spends for patient care.

Based on the information gathered above, calculate the number of physicians (per 100,000) needed for medical services.

2. Criticisms:

   a. Fails to indicate range of appropriate treatment patterns identified by physicians.

   b. Fails to consider substitution for physician services in the delivery of primary care.

   c. Fails to evaluate health outcomes of professionally determined standards.

   d. Approach is narrow because it regards need strictly from a professional viewpoint.

   e. Approach fails to consider alternate means of improving health status.

   f. Leads to oversupply of providers; the actual level of care demanded is far less than predicted by the model since not all of those in need seek care.

METHOD II: Normative forecast based on EVIDENCE IN COMPREHENSIVE PREPAID GROUP PRACTICE

1. This method considers observed demand for manpower in specific existing prepaid group plans to be the best guide for manpower planning since the plans provide members with the necessary high quality care.

2. Criticisms:

a. Averaging across several prepaid plans masks a considerable amount of variation in the populations served, the extent to which outside physicians are consulted, the use of paramedical personnel, and the general health levels.

b. Data is questionable; it has a downward bias due to:

1) Administrative control over the number of physicians, distribution of specialists, length of work week, number of patients seen per hour, etc.
2) Close monitoring of physicians, peer review.
3) Prepaid plans create different incentives (low monetary costs but high access costs in terms of travel and waiting time, emphasis on education and preventive measures).
4) Prepaid systems serve only 5% of the population, and are therefore not representative of the national population.

METHOD III: Forcast based on variations of the RATIO APPROACH (physicians/population)

1. Use the current average ratio in the U.S. as the minimum required physician/population ratio at some future time.
(This method requires the least amount of information.)

2. Use the highest physician/population ratio (the criterion ratio) as the minimum required physician/population ratio at some future time.
(This method has an upward bias.)

3. Forecast expected population growth and future demographic characteristics of the population; project current physician/population ratios (in an area where the population is "adequately served") to the forecasted population.

4. Criticisms:

a. The ratio approach implicitly assumes that the more physicians, the better; that a reduction in the ratio is adverse, although additional doctors may result in unnecessary medical care or under-employment of physicians.

b. Invalid results if the structure of the delivery system changes (as a result of technology or financial mechanisms).

c. National ratios ignore variability in distribution among states, counties, or type of practice.

d. The ratio approach is too rigid; it preserves the current system. It ignores changes in provider productivity and substitution possibilities.

5. Advantages

a. Ratios are relatively simple to calculate.

b. Predicts utilization accurately insofar as underlying conditions which determine supply and demand do not change.

OBJECTIVE II: To develop an economic model of demand

The demand for medical care is dependent upon an individual's underlying health status, perception of the efficacy of medical care, and the cost of getting medical care, where cost is a vector consisting of time costs, money costs, and psychological costs.

METHOD

Estimates the demand function, the future values of each factor in the function, the future values of the parameters. This allows one to predict future utilization rates.

1. Demand functions have been estimated using individuals, groups of individuals, and states as the basic units of observation.

2. In estimating the future values of factors entering the demand function, investigators use age and sex as surrogates for underlying health status, education as a measure of both earned and unearned income, distance to facilities as a measure of time cost, and insurance and Medicaid coverage as measures of the distance between actual and published price to the individual.

3. Income and price elasticities of demand for physician services are calculated.

a. Earnings and wealth are distinguished when estimating income elasticities.

b. Results: as monetary prices of medical care fall and income rises, the quantity of medical services demanded

will also increase; as access costs to medical care drop, demand will increase; as time costs of medical care rise, the number of services demanded declines, especially for those with high opportunity costs of time.

4. Does the supply of medical resources generate its own demand? Does the pattern of recommended care vary with the physician load?

a. Fuchs and Kramer (1972) hypothesized that one of the factors affecting the number of visits demanded per capita was the number of M.D.s per capita since when physicians are abundant, they may order care that is not medically indicated (e.g., unnecessary surgery); when physicians are scarce, however, patients may lower their expectations and handle minor complaints themselves.

b. Method: Using state data, they estimated a five equation model containing a demand function, a supply function, an output per physician function and two identities (quantity of physician services demanded equals quantity supplied; definition of net price). They used two-stage least squares to estimate parameters.

c. Results: Physicians per capita had the highest elasticity and the highest level of significance, indicating that the supply of physicians had the most influence on the demand for care.

d. Conclusions: Fuchs and Kramer conclude that the importance of the physicians per capita variable stems from the physicians' ability to control demand.

This, however, could merely be a simultaneous equation problem in that if physicians move their practices to places where most care was needed, the data would show a close association between supply and demand.

OBJECTIVE III: Use of systems models of health care to examine the simultaneous interaction of supply and demand.

METHOD I: Feldstein (1970, 1971)

1. Developed a 6-equation econometric model (with reference to Medicare).

2. Estimated equations by an instrumental variables technique.

3. Model was designed to explain the variation among states in the endogenous variables.

4. Criticisms:

   a. Model ignores the behavior observed in individual patients, physicians, and hospitals.

   b. Model lacks an output measure of health status.

METHOD II: Yett et. al. (1970, 1971, 1972)

1. A 100-equation (and endogenous variables) model characterizes the system.

2. Submodels (manpower, hospitals, etc.) are joined by interaction equations.

3. Individual decisions (and the factors affecting them) determine each behavioral equation.

4. Uses ordinary least squares to estimate equations individually.

5. Attempts to use simulation techniques to draw implications of the model.

6. Criticisms

   a. Data necessary to estimate model are not available.

   b. Model lacks output measure.

7. Conclusion: To construct a model capable of predicting demand after a structural change (such as that represented by national health insurance or reorganization into health maintenance organizations), to take account of the simultaneity of supply and demand, and to estimate the social welfare implications of changes, one must have a model of the health care system similar to the two presented above, but having the additional property that output is included directly. This is the crucial issue, but, in addition, the system must be estimated using disaggregated data so that it reflects individual consumer and physician preferences while acknowledging that there are other ways of providing care.

OBJECTIVE IV: To examine various criteria for determining a physician shortage

METHOD I: Professional Standards

1. A shortage exists if the number of physicians available at a given place and at a given time is inadequate to meet some professionally defined standard of medical care.

2. Shortages will be perpetual since available manpower will be much less than professionally-defined standards.

3. Criticisms: Although this criterion is simple, shortcomings exist:

a. No assurance that additional physicians would be used

b. No assurance that additional physician services would improve the population's health status

c. No assurance that additional physicians would settle in "underserved" areas

METHOD II: Comparative Ratios

1. A shortage exists in all states (or counties) with a physician/population ratio lower than the mean ratio across states (or counties) or with a physician/population ratio lower than that of the "best" areas - defined by, for example, the areas with the highest ratio.

2. Method always implies a shortage in some areas.

3. The numerator should include only full-time equivalent physicians providing patient care.

4. The denominator should be adjusted for the age, sex, and race of the population.

5. Criticisms: same as for METHOD I (see above).

METHOD III: Demand/Supply Differential

1. A shortage exists if, at current prices, the demand for medical care exceeds the supply of medical care. (This is a strict economic definition of shortage.)

2. A shortage is possible only if the market is not functioning - i.e., if price fails as a rationing device.

3. If physicians are unable to raise prices, the market equilibrates through the use of non-market rationing.

4. Common rationing devices include:

a. Service unavailability (refusals to see new patients, etc.)

b. Long waiting times

c. Deterioration in the product or service itself (small amount of time with the doctor, a less than thorough examination, impersonal care, etc.)

d. Other increased difficulty in gaining access - greater travel distance, less convenient office hours, etc.

5. As high prices are not considered a socially acceptable way of rationing medical care, non-price rationing devices have currently assumed a larger role. This indicates that at current prices, people desire more medical services than are being supplied.

METHOD IV: Rate of Return

1. A shortage exists if there is a high rate of return to physicians at a given time or place.

2. A high rate of return indicates that physicians were able to create an artificially high demand for their services or that supply constraints exist.

3. Criticism: This yields evidence contrary to the assumption of a general shortage: urban areas with the highest physician/population ratios, which should therefore have low prices and low physician incomes, have the highest prices and incomes.

METHOD V: Health Levels

1. This method uses a survey to determine the health of a population, corrected for age, race, sex, and income. The rates of mortality, acute disease, chronic disease, disability and bed days are calculated.

2. Criticism: assumes that medical care is a principal factor influencing health.

3. Alternative to health survey: Assuming that a physician shortage leads individuals to seek care only when they are very ill, the mortality rate and the severity of patient presentation to physicians provides an estimate of the population's health status and physician shortage.

METHOD VI: Community Satisfaction

1. This approach surveys the population to determine whether there is general satisfaction with local medical services.

2. If the health status indices indicate a physician shortage, but the people are satisfied with the level of service and there is no indication of non-market rationing, it makes little sense to provide additional service since it would go unused.

3. This method involves high costs.

4. Conclusion: Clearly, the best approach is to survey the health status of a population and to determine whether additional physicians would be efficacious. This approach, together with one indicating unsatisfied demand, would indicate not only that additional physicians would be used, but that additional services would be efficacious.

OBJECTIVE V: To forecast shortages

METHOD: Forecast shortages on the basis of population forecasts and the predicted number of required physicians.

CRITICISM: Forecasts of both the physician supply and the population are poor. Forecasting is subject to considerable error and estimates tend to cover a wide range.

Forecasts also fail to consider increases in productivity.

CONCLUSION: Forecasters should make their assumptions clear and should present a range of possibilities rather than a single estimate.

Lipson, A.J., CALIFORNIA HEALTH MANPOWER: AN OVERVIEW OF TRENDS AND POLICY ISSUES. Prepared for the State of California Department of Health (Rand: March, 1974).

ESTIMATION OF MANPOWER REQUIREMENTS

No agreement exists on the best way to estimate manpower requirements. A major weakness of the approaches utilized is that they have failed to incorporate adequate measures of the impact of health on individual health status and to utilize methods and assumptions that generate a wide range of forecasts. In addition, a consensus on desirable health goals (i.e., satisfaction of requirements based upon professional judgement vs. public wants vs. economic demand, and improvements in medical care vs. health status) must be reached before one can assess future manpower requirements.

A multitude of factors enter the determination of health manpower requirements: financing, technology, facility location and regulation, patterns of health care delivery, scope and nature of services provided, licensure and certification of personnel, programs of training institutions, and the activities of professional groups. Estimating manpower requirements becomes complex because locational preferences of individual practitioners must be examined. The magnitude of migration from other states and counties (as well as policies affecting migration) also influence future manpower needs. (For example, with respect to physician migration to California, analysis by the Department of Finance revealed that net physician migration as a function of U.S. medical school graduates between 1964 and 1972 varied from 13% in 1966 to 21% in 1969. California physician supply through 1990 was estimated assuming that 13% of projected U.S. medical school graduates will migrate to California. This method, however, assumes a fixed relationship in the future between net M.D. immigration to California and U.S. medical school graduates as a basis for projecting physician supply. This assumed coefficient masks the interactions of complex variables influencing physician location decisions, many of which are not well understood.)

Medical education programs can also have a significant impact of the supply and distribution of health professionals and the quality of health services provided. Moreover, changing patterns of health delivery and financing and lack of knowledge about health delivery and financing and lack of knowledge about health production function (e.g., the most effective combination of resources required to produce certain outcomes) make manpower requirement projections highly uncertain. A basic policy issue is the extent to which the number of health personnel should be increased as opposed to improving the efficiency and effectiveness of medical care delivery.

The report concludes that there is no consensus about how to best estimate manpower requirements and the complex factors that influence physician location. Planners and policy-makers should therefore focus on intermediate-run policies that emphasize policy instruments over which the state has some control and on measures that are likely to affect the state's ability to meet its goals.

HEALTH MANPOWER LICENSURE

Personnel licensure significantly affects the supply and demand of allied health workers (with respect to vertical and lateral career mobility, delegation of tasks, etc.). Lipson discusses the implications of present licensure requirements and possible reforms.

Although the original purpose of health professional licensure laws was to protect the public from abuse, many authorities have concluded that current licensure practice tends to limit the rational allocation of manpower resources; restrictive and artificial requirements block the delegation of tasks and hamper career mobility. It is alleged that these laws increase costs and have relatively little impact on the quality of care or the protection of public health and safety because licensure boards have not effectively monitored licensure performance. Moreover, proliferation of health occupations and fragmentation of the present personnel licensure system promote a patchwork of statutorily "walled" categories that tend to inhibit optimal resource allocation. In addition, changing and emerging health care roles have made it difficult to determine which tasks are or should be performed by different professionals and how these various professional roles interrelate.

This is not to say the removal of licensure impediments would by itself result in ideal allocation of manpower resources. Many factors influence manpower allocation: credentialing and certification by private bodies and educational institutions, facility licensure, financing, wages and working conditions. Actions of professional associations, personnel and staff requiremements of payment programs, among others, probably have as great or probably greater impact on manpower utilization than do licensure requirements <u>per se</u>.

PROPOSED LICENSURE REFORMS include the establishment of a single licensure board with jurisdiction over all allied health occupations. Such a board, which would contain public representatives, could possibly relate educational and other requirements to health tasks and reduce fragmentation of licensed occupations. Equivalency qualifications (used to equate nonformal learning or experience with formal academic training) and proficiency examinations (aimed at measuring an individual's capability to perform a job at a certain level) could enhance career mobility.

In addition to changes in licensure methods for specific categories of health personnel, suggestions have been made for "institutional licensure." Under this approach, advocated by Professor Nathan Hershey of the Unversity of Pittsburgh, health personnel licensing would be integrated with the present system of facility licensure. A state agency (partially composed of consumers) would directly regulate only health institutions to ensure that they meet "objective criteria relating to safe and competent performance." Health institutions would develop and periodically submit to the state agency a plan for selection and utilization of staff including job classifications. Hershey claims institutional licensure to be superior in accountability to the public. But if each institution were to develop its own job classification and training system, confusion could result and there might be a negative effect on mobility between institutions and individual career viability.

H.M. Goldstein, et. al., (RESTRUCTURING PARAMEDICAL OCCUPATIONS: A CASE STUDY, Boston: Northeastern University Departments of Economics, January, 1972) proposed creation of a new career ladder consisting of a progression of paramedical occupations structured around nursing and medicine. An individual would progress from nurse aide to nursing assistant or medical assistant to physician's assistant based upon experience and on-the-job training.

Dr. Roemer ("Licensing and Regulation of Medical and Medical Related Practitioners in Health Service Teams," MEDICAL CARE, Vol. 9, Jan. - Feb., 1971, pp. 42-54.) has proposed a health team licensure system in which the head of the team would be licensed and authorized to supervise certain unlicensed personnel on his team in accordance with patient care criteria.

Thus, a variety of measures to make licensure systems more accountable to the public, more flexible, and more effective in regulating quality and distribution have been suggested. Little empirical work has been done either to determine the impact of licensure regulations on the behavior of health professionals or to assess the potential impact of major changes.

In the past, attempts to reform licensure laws have in part foundered on this dilemma: proposals for change have remained undocumented because existing licensure laws and regulations discourage innovation and controlled experimentation with new forms of delivery and nontraditional allocation of health manpower tasks. Significantly, in a move to promote innovation, the Legislature of 1972 authorized the State Health Department to exempt "experimental health manpower projects" from current licensure requirements. This legislation had three primary objectives:

1. To encourage experimentation by removing legal barriers to it (i.e., questions about the legality of training programs and the legal status of trainees themselves).

2. To assess more systematically the need for new or expanded roles and to evaluate program results.

3. To develop suggestions for reform of licensure laws that flow from the experience of the projects themselves.

Specifically, projects sponsored by nonprofit educational institutions, hospitals, or clinics are to be approved for expanded-role medical auxiliaries, nurses, dentists, and personnel in maternal care, pharmacy, and mental health.

Oklahoma Interagency Task Force for Health Manpower Data, OKLAHOMA HEALTH MANPOWER, 1975-1980, (Stillwater: Occupational Training Information Service, 1975).

OBJECTIVE

To provide comprehensive, relevant data to meet a variety of user needs.

METHODOLOGY

Survey methods were employed. In general, forecasts were made using ratio methods or job vacancy methods.

CONCLUSION

While projections were made for numerous health skills categories, the following projections of manpower requirements or "needs" are of special interest.

PERCENT CHANGE

	1975 - 76	1975 - 80
Dietician	.0	.0
Medical Technologist	10.0	27.4
Physical Therapist	20.0	45.0
Occupational Therapist	33.3	70.0
Audiologist	29.4	82.4
Speech Pathologist	17.6	74.5
Health Administrator	1.4	2.8

Reinhardt, U.E., "A Production Function for Physician Services," REVIEW OF ECONOMICS AND STATISTICS, Vol. 54, no. 1 (February, 1972), pp. 55-66.

OBJECTIVE

To empirically identify the effects of auxiliary personnel and of the mode of practice on the physicians rate of output).

METHODOLOGY

The unit of analysis in this study is an office-based practice of self-employed American physicians. The author specifies a production function for which all inputs are not necessarily essential. For example, the production function allows a physician to operate his practice without any auxiliary personnel. The data employed in the ordinary least squares estimation consists of the survey responses of roughly 1000 physicians.

CONCLUSIONS

The analysis leads to the conclusion that the average American physician could profitably employ roughly twice the number of aides he currently employs and thus increase his hourly rate of output by about 25 percent. This conclusion supports the thesis that American physicians tend to be wasteful in the use of their scarcest and most expensive resource.

Reinhardt, U.E., "Manpower Substitution and Productivity in Medical Practice: Review of Research," HEALTH SERVICES RESEARCH, Vol. 8, no. 3 (Fall, 1973), pp. 200-27.

OBJECTIVE

To critically review the literature on the production of ambulatory health care and to identify technically feasible opportunities for manpower substitution.

METHODOLOGY

The distinct methodological approaches underlying mathematical models are presented in synopsis, and their inherent strengths and weaknesses contrasted. Special emphasis is given to the specification and estimation of production functions employed by other studies.

CONCLUSION

Research has so far indicated rather consistently that the typical provider of ambulatory care has not pushed the substitution of paramedical for medical manpower to the extent that is technically feasible and economically advantageous.

Sattinger, Michael. "Alternative Models of the Market for Registered Nurses." JOURNAL OF ECONOMICS AND BUSINESS. Vol. 28, no. 1, Fall, 1975.

PERFECT COMPETITION

Kenneth Arrow and William Capron (AJE, "Dynamic Shortages and Price Rises: the Engineer-Scientist Case," 73-292-308, May '59) developed a dynamic model in which lags in the adjustment of wages lead to shortages when demand increases relative to supply. The simple linear formulation of the model permits one to perform a crude test of whether the behavior of the market for nurses is consistent with perfect competition. Perfect competition, as represented by the Arrow and Capron model alone, however, cannot explain the phenomenon of shortages of nurses in the market. The reasons are:

1. Based on postwar wage responses to a supply shortage, the lag would have to be unreasonably long.

2. Upon substitution of available statistics into the equation for the long-run limit of shortages, the elasticity of demand implied by the Arrow and Capron model would have to be fairly high for all reasonable levels of the elasticity of supply of registered nurses.

MONOPSONY

Similarly, the strict monopsony model fails to accurately describe the nurse shortage:

1. Assuming that the long-run elasticity of supply of registered nurses is the same for the individual, separated monopsonists as it is for the industry as a whole, the elasticity of the marginal revenue product of nurses with respect to the wage would be greater than five. The high elasticity would seem to be inconsistent with the wide variability in the use of nurses in hospitals.

2. The model makes the hospital the sole villain. Accordihg to the theory, hospitals, the major employers of nurses, were responsible for the budgeted vacancies reported. By simply raising the wage to the value of an extra nurse's services, the shortages could have been eliminated.

Most analysts of the postwar market for nurses, however, argue that the nurse shortage was more serious than indicated by the monopsony model and that the protestations of hospitals were genuine.

TWO-PART TARIFF MODELS OF HUMAN CAPITAL

In view of the shortcomings discussed above, the author suggests a third market structure that arises from mobility in imperfectly competitive labor markets. The model includes both the training and the employment of workers.

Just as a firm selling two goods used together for one purpose sets two prices, or a two-part tariff, a firm training employees and later hiring them also must set two prices: one for the training and one for the employment. The training may be considered the fixed part and the employment the variable part of a two-part transaction. The problem for the firm is to decide what wage to pay and what fee to charge for training so as to maximize the sum of profits from both training and employing workers. In analogy to the case of a firm setting a two-part tariff, the best solution for the training firm is to set the wage equal to the marginal revenue product of labor and to receive all profits in the form of a training fee greater than the cost of training. The training fee is set to equate the excess of the fee over the training costs for one more entrant with the loss in fee receipts from lowering the fee enough to draw in one more employee.

If the employee is mobile, however, the connections between the wage paid and the fee a firm can charge breaks down. It will no longer be possible for a firm to capture all of the producer's surplus from an employee and the welfare losses will be substantially greater.

The mobile employee, for example, will compare the training fee that must be paid to the given firm with the wages that are paid by firms elsewhere. Thus, if most of a firm's workers are trained elsewhere and later migrate to the area, the firm finds that it can act like a traditional monopsonist by paying a wage less than marginal revenue product. In addition, an increase in the training fee may not bear significant consequences if most of the hospital's laborers have been trained elsewhere. In the extreme case, the markets for training and trained labor are independent, and the firm acts as a monopolist in the first case and a monopsonist in the second. At the industry level, mobility results in two few individuals being trained; each employee supplies too little labor since the training fee is greater than the training cost and the wage is less than marginal revenue product.

The author states that two-part tariff models can be extended to apply to on-the-job training programs. Furthermore, the mobility model can be developed to show firm behavior in employing different groups.

Importantly, the two-part tariff model attributes the chronic postwar nurse shortage to the mobility of nurses among hospitals. Due to nurse mobility, hospitals had less incentive to consider the effect of wage rates on entry. As a change in wage rates would affect only the supply of labor through its effect on the few nurses who were trained by the hospital and chose to stay on, the hospital was led to lower the wage to below the value of an extra nurse's services.

Decentralization of hospital decision-making may account for the reporting of shortages rather than the raising of wage rates to eliminate the shortage. Sattinger suggests that departments consider wage as given since the central hospital administration determines the wage rate, and hire until the value of an extra nurse's service was equal to the wage. Further unlike a hospital in a monopsony situation, the individual hospital would have little control over the supply of nursing services. An increase in the wage only would increase the amount of labor supplied by nurses already trained and would have little effect on the number of potential employees. Lowering the tuition also would have had little effect because few of the extra nurses trained would stay on. Misallocations would come about as a result of the collective behavior of hospitals. Since the wage would be less than the value of an extra nurse's services, too little labor would be supplied by nurses already trained.

The two-part tariff models also provide an explanation of the decline of diploma schools of nursing. Associate degree and baccalaureate programs increase the number of nurses not trained by hospitals. According to the model of the firm facing mobility, this factor would lead the hospital to charge even higher tuition and to train even fewer students. But, since these alternative programs reduce the ability of a hospital to charge a tuition greater than the cost of the training, the incentives of hospitals to subsidize nursing education declines.

In the late 60's, the nurse shortage seemed less acute. Sattinger uses the mobility concept to explain this phenomenon. In the presence of mobility, individual hospitals have an incentive to draw in nurses from other areas. In response to a large increase in demand, hospitals were led to intensify their recruitment efforts outside their own areas. This activity increased the wage-elasticity of supply faced by individual hospitals. As a result, shortage went down, and the salaries went up.

Sattinger concludes that while the two-part tariff model has several advantages over the perfectly competitive and monopsony models in explaining the market for nurses, limited data precludes proof of the model's validity.

Skaar, Janet L., ASSESSMENT OF MANPOWER NEEDS AND MANPOWER POTENTIALS OF DIETICIANS IN CALIFORNIA, unpublished Master's degree thesis, San Francisco State University, San Francisco, December, 1975.

OBJECTIVE

To investigate current manpower trends and future needs of the profession of dietetics in California in order to serve as a basis for projecting the need for alternative training programs.

METHODOLOGY

Employing survey data collected from health care facilities and from colleges and universities, the author obtains frequencies and percentages for the responses for each question. Distributions are cross-tabulated by counties, part-time vs. full-time employment, etc.

CONCLUSIONS

There will be approximately 60 unfilled positions for qualified dieticians in the state of California. It is argued that there is an inadequate number of training programs to fulfill the projected demands for dieticians.

Smith, Kenneth R., Marianne Miller, and Fredrick L. Gollagday, "An Analysis of the Optimal Use of Inputs in the Production of Medical Services," JOURNAL OF HUMAN RESOURCES, Vol. 7, no. 2 (Spring, 1972), pp. 208-25.

OBJECTIVE

To explore the implications of employing physicians' assistants in delivering primary care. It seeks to identify the optimal role of paramedical personnel and to assess the impact of efficient delegation of tasks on the productivity of the physician, his opportunities for leisure, and the cost of care.

METHODOLOGY

The authors develop a theoretical model to address four major issues: (1) the question of the impact on physician productivity; (2) the implications of delegation for the physician's leisure time and the cost to the physician of additional leisure; (3) the determination of the optimal task profile for delegation; and (4) the implication of institutional constraints on the role of the physicians' assistant for physician's productivity. The empirical effect determines the pattern of demands for medical services, the potential technology of cure, and the probable prices of hired health workers. This information is analyzed in the activity analysis model of the practice to identify and assess the implications of efficient patterns of delegation.

CONCLUSIONS

The following conclusions are made: (1) the physicians' assistant increases the productivity of the physician by 74% for unclassified tasks and 49% for classified tasks; (2) the input of physician time to serve a respresentative practice might be reduced from 28 hours a week to approximately 13.9 hours; (3) the delegation of tasks allows the practice to increase income by 160 percent; (4) an RN can be efficiently employed in a practice serving more than 138 patients per week while patient loads exceeding 150 may efficiently employ a physician's assistant along with an RN, LPN, and medical assistant.

Stewart, Charles T., "Allocation of Resources to Health," JOURNAL OF HUMAN RESOURCES, Vol. 6, no. 1 (Winter, 1971), pp. 103-22.

OBJECTIVE

To suggest a classification of activities whose primary objective is the improvement and/or preservation of health. This classification aims to facilitate rational decision-making in the health area by grouping alternative means to the same objective and organizing systems and subsystems into a functional hierarchy.

METHODOLOGY

A fourfold classification of resources devoted to health is employed: treatment, prevention, information, and research. The author tests his model using data on all nations in the Western Hemisphere plus Puerto Rico. Three indicants of productivity were used: life expectancy at birth, infant death rates, and child death rates. These indicants were correlated with other indicators such as MD/population ratio, general hospital bed/population ratio, potable water, etc.

CONCLUSIONS

For underdeveloped countries all health resources should be concentrated on prevention rather than information, treatment, or research, except where these functions complement prevention. In addition, too many resources are presently being allocated to treatment; too few resources are being allocated to prevention and research.

Sturm, Herman M. "Technological Developments and Their Effects Upon Health Manpower", MONTHLY LABOR REVIEW (January, 1967), pp.1-8.

OBJECTIVE I: To examine the effects of technological change upon health manpower.

The size and type of manpower supply that will be required in health service establishments in the future depend on three interrelated factors.

1. Total demand for health services (determined by trends in birth rate, the general health of the population, the ability and willingness of families and governments to spend money on health care).

2. The nature and composition of health service facilities and activities (i.e., the use of nursing home beds as opposed to hospital beds, an increased use of surgery, etc.)

3. Productivity trends: changes in the ratio of output to input (as measured in units of health service performed per man-hour) in the industry as a whole - which in turn will be affected by the types of health facilities used and by improved efficiency in specific activities.

CONCLUSIONS: Based on observations of the changes which have occurred in the delivery of various health services, the authors conclude:

1. Specific technological advances affect manpower requirements in the health industry differently; innovations in disease prevention methods have directly opposite effects from improvements in disease detection. For example, polio vaccines and similar preventives have greatly reduced needs for manpower to attend victims of communicable diseases. On the other hand, improvements in laboratory procedures and other methods of detecting illness have resulted in substantial increases in the number of patients admitted, and therefore, in expanding hospital manpower requirements.

2. The effects of advances in patient care technology on health manpower requirements are likely to be more substantial and predictable than those resulting from advances in disease prevention or detection.

   a. Assuming continued (and perhaps accelerated) growth in the demand for clinical laboratory tests, labor-saving effects of automated equipment will only partially offset the demand for medical technologists.

b. Greater utilization of automated equipment and semi-skilled laboratory assistants will free highly trained technical staff for more advanced and complex tasks.

c. Sophisticated equipment, while able to increase the productivity of technicians, may also require more highly trained technicians.

d. As evident in surgical techniques, advances necessitate more highly specialized health workers. This elicits changes in the job content and the nature of traditional health jobs.

OBJECTIVE II: To estimate full-time equivalent employment in major health occupation groups for 1965, 1970 and 1975.

METHODOLOGY

The projections were developed by translating expected demand, changes in technology, and related factors affecting employment in health service establishments into numbers of full-time equivalent jobs. The estimates are based on available statistical evidence and qualitative data, supplemented, where necessary, by judgments obtained in interviews.

CONCLUSIONS

1. According to the projections, between 1965 and 1975, the number of full-time equivalent jobs in the health service industry will increase 33%.

2. Jobs in X-ray and clinical laboratory departments are likely to expand twice as fast as jobs for health service employees in general.

3. The expansion of administrative and office personnel is expected to decrease between 1965 and 1975.

4. As a result of improvements in surgical and clinical techniques, an above average increase in the number of jobs for rehabilitative and other technical services can be expected.

In general, the effects of innovations in the health field will be to raise the quality of health care, increase the demand for highly qualified manpower trained in new skills, and reduce demands for less skilled labor. Many innovations will not only create new kinds of jobs, but will also broaden existing jobs by requiring that they incorporate new duties calling for specialized knowledge.

U.S. Department of Labor, Bureau of Labor Statistics, OCCUPATIONAL SUPPLY: CONCEPTS AND SOURCES OF DATA FOR MANPOWER ANALYSIS. Bulletin 1816, 1974.

A MODEL OF OCCUPATIONAL SUPPLY STRUCTURE

This model analyzes an occupation's supply structure and identifies the factors affecting the flow of workers into and out of an occupation.

1. Definitions

   a. Supply: the number of individuals working or seeking work in an occupation at a given time. (Note that this definition does not describe a functional relationship between wages and workers' willingness to offer their services.)

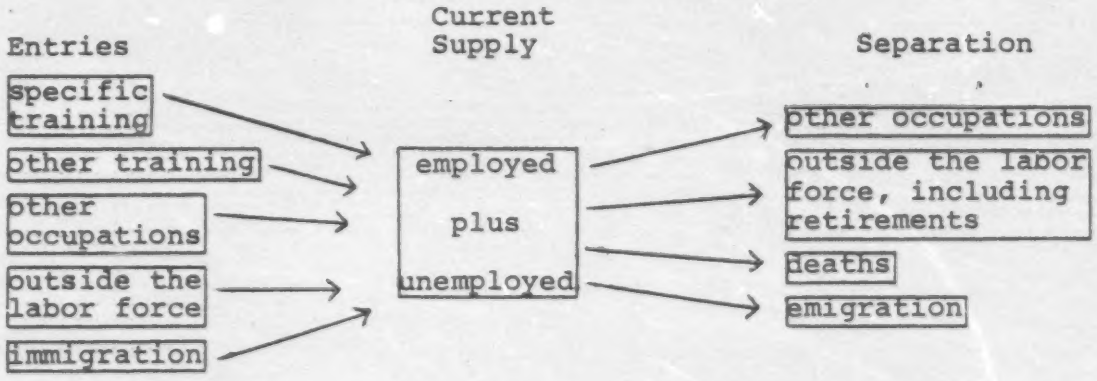
   b. Current Supply: current employment (primarily because current employment is often the only available information. A more accurate definition, however could include the number of unemployed persons seeking work in the occupation at a given time).

   c. Potential Supply: current supply, plus persons qualified for the job, but who are not members of the current supply. (In a shortage situation, the potential supply represents a means of relieving the shortage by attracting the potential supply into the current labor force. In a surplus, the potential supply may represent the underemployment of trained workers).

2. Description of the Model

WORKER FLOW

INTO AND OUT OF AN OCCUPATION



3. Using the Model

a. Specify the Model

1) Specify the geographic area (the economic labor market area applicable to the particular occupation), occupational coverage, time frame of the analysis.

2) Examine the occupation's skill content, traditional training and hiring requirements, institutional characteristics (unionism, licensure), and personal characteristics of workers.

3) The model may be extremely difficult to specify (and thus not readily adaptable to structural analysis) if the sources of supply, sources of training, or skill content, are diverse.

4) Improper definition of the economic labor market for an occupation will tend to limit the ultimate usefulness of the analysis. Often, users will find their flexibility in defining the geographic area severely limited since most data collection is conducted within politically defined boundaries.

5) Care must be exercised in selecting the appropriate definition of an occupation. Often one must choose among various levels of skill, or between limited and broad areas of specialty. The criteria for selection depend mainly on the particular use of the analysis.

6) The appropriate time frame depends on the user's needs and the availability of data. Projecting supply conditions usually depends on the availability of enough historical data for trend analysis. Ideally, the data should permit analysis of the flows of workers into and out of the occupation through a span long enough to measure rates of flow with reasonable reliability and to observe how these rates change in response to various conditions.

b. Estimate Current Supply

Determine the number of persons employed and the number seeking work in the occupation. (Unemployment information serves as a good indicator of shortage/surplus conditions.)

c. Identify and Estimate Entries

1) Method 1: Employer interviews, labor union, professional organizations, government regulatory or

licensing agencies can identify entry qualifications and significant sources of entry.

2) Method 2: Information on the sources of entrants may be obtained by examining the characteristics of workers already employed in the occupation. The investigation should focus on workers' skills, their training and experience, and their type of entry. Data on personal characteristics of entrants (such as age, sex, reasons for re-entry of persons outside the labor force, and previous occupations) are useful for identifying and analyzing patterns of entry, re-entry, and transfer.

3) Obtain data on the number of entrants from each source:

   -determine the number of graduates or training completions during the appropriate time period;
   -determine the number of graduates who actually enter the occupation.

   Based on the above, compute an entry rate. Entry rates should take into account graduates who are already employed in the occupation before they complete their training, and who therefore cannot be counted as new entrants.

   Obtain information on factors affecting entry rates, such as relative wages or job opportunities.

4) Estimating occupational transfers requires longitudinal data that identify the types of transfers and allow the development of rates of transfer into and out of the appropriate occupations. This may be expressed as an average annual flow.

5) Measuring the number of entrants from immigration requires data on the occupations of individuals entering the country from abroad, as well as information or assumptions about their expected participation in the labor force. In the absence of detailed data, a residual method may be employed to estimate net migration. If all other components of the change in supply from one period to the next can be measured, net migration is assumed to be equal to the difference between the observed change in supply and the changes accounted for by the other components.

d. Identify and Estimate Separations

1) This is fairly straightforward as there are only 4 types of separations: occupational transfers, labor force separations, deaths, and emigration.

2) Use the proportion of workers who transfer out each year to determine the rates of occupational transfer and emigration. Complete analysis would require identification of occupations and areas to which workers transfer as well as the reasons for separation.

FUNCTIONAL MODEL OF OCCUPATIONAL SUPPLY

1. A functional supply model views the wage rate as the primary mechanism for interaction between supply and demand.

a. Note that this does not imply that the wage rate is the only factor affecting supply; individual preferences, abilities, and non-monetary incentives also enter the decision.

b. Empirical evidence is necessary to determine the responsiveness of workers to wages; the model cannot a priori describe the relationship between wages and supply.

c. A functional supply model can describe the effects of flexible or inflexible wages, monopsony, immobility, time lags, and other market conditions on supply.

2. Data requirements

a. Relative wages to estimate the relationship between wages and various aspects of supply. (Relative wage comparisons should reflect actual alternatives faced by individual workers and the alternatives specified in the structural model - i.e., comparisons between the given occupation and the occupations workers transfer to and from, or between entry rates into a given occupation or other occupations for which the training is applicable).

b. Enough time series or cross-section observations for multivariate analysis.

3. Elasticity

a. (definition) Elasticity of supply measures the responsiveness of workers to changing economic incentives, especially wage rates.

(1) Coefficient of elasticity: η_{NW} $\Delta N/N \div \Delta W/N$

(2) $\eta > 1$ implies elasticity; $0 < \eta < 1$, inelasticity; and, $\eta = 0$, perfect inelasticity.

(3) High elasticity indicates that the market adjusts through the wage mechanism and therefore, that policy actions affecting supply are probably unnecessary.

b. Cross elasticity: change in supply resulting from a change in the wages of a related occupation (A)

$$\eta_{NA} = \Delta N/N \div \Delta W/W$$

Cross elasticities aid occupational definition. That is, if the occupation is too narrowly defined, high cross elasticities with other occupations will indicate ease of transferring skills. It also gives an indication of how occupational supply will react to changing conditions or policies for related occupations.

c. Determinants of elasticity: Analysis of factors that determine elasticity can indicate possible policies that will increase elasticity--i.e., adjusting supply while minimizing the disturbance of relative wage levels.

(1) Required skill level: Occupations with high skill levels are likely to have inelastic supply in the short run.

(2) Specificity of skill: Inability to easily transfer skills to other occupations may limit elasticity.

(3) Nonwage incentives and barriers: These may affect the worker's ability or willingness to enter or leave an occupation. (e.g., union rules, racial discrimination, lack of information about alternative jobs, licensing rules or fees, seniority rights, job status, working conditions, training subsidies or loans, etc.)

4. Supply-Demand Imbalances

Identification of supply-demand imbalances and designing policies to treat imbalances and their side effects require careful application of functional analysis. Policy-makers must know how wage levels have changed in the past, and how workers and employers have responded to these changes, in order to understand the causes and remedies for any imbalances that might arise.

a. (definition) A SHORTAGE occurs when employers seek to hire more workers than are willing to work at the <u>given wage rate</u>.

b. Reasons for the persistence of disequilibrium:

(1) Inflexible wages due to legal constraints or rigid internal wage structures

(2) Lack of information about wage adjustments occurring elsewhere in the economy

(3) Training lag (training new workers and getting them into the job market requires long periods of time; it may also be difficult or expensive)

(4) Low social status of the occupation

(5) Poor working conditions

c. "Dynamic Shortage" Model (Kenneth Arrow and W.M. Capron, "Dynamic Shortages and Price Rises: the Engineer-Scientist Case," QJE; 5/59, pp. 292-308.)

A dynamic shortage arises when supply fails to catch up to continually expanding demand. Wage rates also continue to rise. The shortage remains as long as demand continues to increase at a faster rate than that which would allow supply to catch up to current wage levels.

d. "Incomplete Adjustment" Model (Richard B. Freeman, THE MARKET FOR COLLEGE TRAINED MANPOWER: A STUDY IN THE ECONOMICS OF CAREER CHOICE, Cambridge: Harvard University Press, 1971, pp. 22-27.)

If supply is inelastic in the short run, an expansion of demand will cause relative wages to rise. Higher wages lead to a modest increase in the number of entrants and an ensuing modest reduction in relative wages. As this pattern is repeated over time, relative wages and supply approach equilibrium. Incomplete adjustment occurs when an increase in actual wages cannot attract enough new entrants to reach equilibrium: i.e., when wage expectations are lower than actual wages.

e. Cobweb Model (Freeman, Ibid.)

An increase in demand causes wages to rise, attracting a large number of workers into the occupation. Because workers enter in such large numbers, wages subsequently fall, leading to a reduction in supply in the next period. Wages and the number of entrants continue to oscillate in smaller and smaller magnitudes until equilibrium is reached several periods later.

This model is more likely to apply if supply is elastic since a change in wages will produce a change in the supply large enough to overshoot equilibrium.

f. Projected Demand Shortfall

Comparisons of independently derived projections or "requirements" and supply for some target year can project shortages of workers. Appropriate policy action (reduction of entry costs; substitution of machines or other kinds of manpower for workers in shortage occupations) is undertaken. Projections unfortunately are made with little or no consideration of how well the wage mechanism operates in the particular market, and rarely make explicit assumptions about relative wages. They usually carry the implicit notion that the market adjustment processes are defective or at least subject to extended lags.

g. Other usages of the term, "shortage"

(1) A confusing use of the term "shortage" arises when a significant increase in demand and/or decrease in supply has resulted in a major rise in wages. Although this is not a shortage in an economic sense (since the wages rose as much as required to clear the market under the new supply-demand conditions), many employers who now find the wage so high they no longer hire as many workers will describe the situation as a "shortage." The economist would not describe this change as a shortage because there is no evidence that wages did not rise sufficiently to eliminate excess demand.

(2) A normative use of the term "shortage" arises when observers believe that demand (and therefore, supply) should be higher than it is--there is a doctor "shortage" because a larger number of doctors is needed to achieve some given standard.

h. (definition) A SURPLUS occurs when more workers are willing to work than employers are willing to hire at the given wage rate. A fall in the wage rate should eliminate the surplus. Confusion over the economic meaning of a surplus is apparent. Observers consider situations where relative wages are falling in response to an increase in supply or a decrease in demand to be surpluses. Policies to prevent declining wages by reducing supply or by increasing demand may be proposed as remedies to such "surpluses." The important distinction is that these policies are not treating a surplus, since the surplus is eliminated by allowing relative wages to fall to a new equilibrium. The policies are instead addressed to the social costs imposed by falling relative wages: decreased income, unemployment, immobility, and underutilization of skills.

U.S. Department of Labor; W. Willard Wirtz, Secretary. TECHNOLOGY AND MANPOWER IN HEALTH SERVICE INDUSTRY 1965-1975. Manpower Research Bulletin, No. 14, May, 1967.

OBJECTIVE

The report is particularly concerned with the relationship between technological advances and other developments that will affect manpower in the health service industry during the decade 1965-1975. It attempts to project the size and job content of key health occupations and to point out problems and opportunities that will have to be considered in developing health manpower projects and policies.

METHOD

1. Definition of Health Service Employees

The study was mainly concerned with employees on payrolls of patient care institutions (private and government hospitals, nursing homes, offices, and clinics of private medical and other individual practitioners and groups, etc.). Self-employed professionals, proprietors of health establishments, students and volunteers were excluded.

(Note that estimates of employment in health-related activities differ depending on the definition of health service employees. Thus, the definition used must be clearly stated.)

2. Determination of Manpower Shortage

a. Estimate the number of vacant jobs employers are actually trying to fill.

b. In 1965, the U.S. Employment Service, in THE CAREER GUIDE FOR DEMAND OCCUPATIONS, listed occupations in critical demand. (The list is based on nationwide information developed by the Bureaus of Apprenticeship and Training, Employment, Security, and Labor Statistics, and by the Women's Bureau, all of the Department of Labor.)

Physical and occupational therapists, dieticians, pharmacists, and medical technologists were among the 17 health occupations included in the listing.

c. Shortage of Medical Laboratory Personnel

(1) Confusion arises due to self-constituted registries for medical laboratory personnel. Although these lack recognition by organized medical groups, they offer examinations and grant registration and privileges.

Qualification standards tend to be lower and in some groups confer the title of "medical technologist" to persons with brief, inadequate training in commercial laboratories. Confusion also stems from the use of the term "medical technologist" as a generic designation for persons who perform medical laboratory tests of any kind.

(2) In recent years the use of laboratory tests has increased, but the supply of medical technologists, cytologists, certified laboratory assistants and histological technicians has not kept pace with the expanded demand for their skills.

(3) Reactions to the shortage include the rise of commercial schools offering certificates after inadequate training courses; hospital reduction or elimination of laboratory services requested by physicians for their office patients; physician reliance upon their own less adequate testing facilities or on commercial labs of uncertain quality.

3) Determination of Technological Development's Affect on Manpower

(Technological change has been described as any change in the method of producing or distributing goods or services resulting from the direct application of scientific or engineering principles.)

a. To estimate the effects of technological developments on manhour requirements for patient care during the next decade, one must forecast the pace at which innovations will spread--how long it will take from the time of their invention or discovery until they are adopted on a wide scale.

b. Conclusions

(1) Whatever the possibilities may be for relieving manpower shortages, technological advances result in new kinds of jobs and unique changes in the content of existing jobs.

(2) The labor-saving effects of automated equipment have offset only partially the continuing shortage of medical technologists. Increased demand for laboratory services (which is expected to continue) will raise the need for highly trained technologists.

4. Projections of Health Manpower Requirements: 1975

a. The number and kinds of manpower that will be required in health service establishments in the future depend on:

(1) The expected total demand for health services. This will be influenced by factors such as the birth rate, the general health of the population, the ability and willingness of families and government to finance health care.

(2) The anticipated nature and composition of health service facilities and activities. This is based on expected shifts in the importance of required types of services.

(3) Productivity trends--changes in the ratio of output, measured in units of health service performed, to input, measured in manhours.

(4) State and federal legislation. Legislation often states specific personnel standards which health institutions must fulfill before receiving reimbursement.

b. Projections of employee/patient ratios in hospitals and nursing homes.

(1) AHA reports the employee/patient ratio for inpatients (in terms of number of full-time equivalent employees per 100 patients)

(2) The AHA figure is adjusted to take separate account of employees actually working with inpatient cases and employees actually allocated to outpatients and home care, allowing for a large margin of error in this separation.

(3) Assumptions underlying 1975 projected employee/patient ratios

-By the end of the '65-'75 period, the employee/patient ratios in inpatient, outpatient, home care, and nursing home services will have continued to grow at varying rates. The varying rates reflect a probable greater increase in intensity of care among outpatients and home care cases than among inpatients, and also some offsetting productivity improvement in hospital inpatient care;

-A substantial growth in the importance and therefore the weighting effect, of the services other than inpatient care during the decade.

(4) Thus, the crux of the projections is the forecasted shift toward the importance of patient care in outpatient clinics, home care services, and nursing homes (vs. inpatient care) in the 10 year span. While estimates of the average numbers of hospital outpatient and home care and nursing home patients in 1975 are based on sparse data and are subject to considerable error, the important point is that this increase will be larger than the increase in the number of hospital inpatients.

(5) Adjustments or Projections

The employment projections obtained above were checked by independent, simply extrapolated projections, reflecting assumptions that the increased demand for manpower in short-term hospitals resulting from Medicare and related programs will not be paralleled by equivalent increases in federal and other government hospitals. These hospitals are not likely to gain patients as a result of the Medicare program and, in fact, they may lose some patients to voluntary and proprietary hospitals as a result of Medicare.

A final check was made by totaling independently the calculations of expected demands for major occupational groups. The original projections had to be modified only slightly on the basis of these checks.

c. The projections of employment for the various occupational groups were made up individually, according to guidelines set by various benchmarks, studies, and opinions on predicted needs for each group. The final figures were in some instances adjusted or smoothed as indicated by evidence such as data on expected expansion in demands for particular activities (lab tests, X-rays, etc.), estimates of the expected effects of labor-saving technological developments, and by further consultation with experts. The final projections of employment among occupational groups, when totaled, were found to be close to the total employment projected for 1975 as derived separately on the basis of assumptions tied to total employee/patient ratios.

It may be noted that the estimates of 1965-1975 growth for the health service industry closely coincide with those stated for SIC 80 (Medical and Other Health Services) in the study by the U.S. Labor Department's Bureau of Labor Statistics (published as AMERICA'S INDUSTRIAL AND OCCUPATIONAL MANPOWER REQUIREMENTS, 1964-1975) if allowances are made for differences in the number of years, treatment of full- and part-time employment, and industry definition.

d. Sample Projections

OCCUPATION GROUP	Number of Employees (Thousands) '65	'70	'75
Dietary Personnel	235	265	295
Medical Laboratory Personnel	100	130	160
Pharmacists	11	12	13
Rehabilitative & Other Technicians	120	150	185

These projections, in terms of full-time equivalent jobs, reflect the expected changes in future demand for health services, productivity and technology, and related factors affecting employment in health services establishments. The expectations were based partly on statistical evidence, partly on factual data, and somewhat on subjective judgments. The numbers of jobs projected on the basis of these expectations, then, had to be estimated by using a mixture of statistical calculations, expert opinion, and ordinary judgment.

Jobs in X-ray and clinical laboratory departments are likely to expand twice as fast as jobs for health service employees in general, mainly because of the sharp increases in the use of X-ray techniques and clinical laboratory testing. Rising demand for employees in these departments will be only partly offset by the spread of automated laboratory equipment.

Rehabilitative and other technicians will also experience above average increases in the number of jobs, chiefly as a result of improvements in surgery and other clinical techniques requiring intensive care of patients by qualified paramedical personnel.

Employment expansion between 1965 and 1975 among dietary personnel and pharmacists will probably be slower.

e. Limitations of Projections

(1) The study used a limited definition of health manpower. Total employment fails to reflect expansions in the number in independent practice, in schools, etc.

(2) The study includes only government-operated hospital and nursing homes. New government-sponsored activities for providing health services through the employment of disadvantaged persons may significantly increase demand for health manpower.

(3) The reliability of the projection is affected by gaps in data in certain important areas. The following areas lack up-to-date, reliable information: spread of technological developments in health facilities; productivity data; age, description, and rate of replacement of hospital structures and equipment.

(4) Lack of data is one of the reasons for omission from this study of projections for individual occupation groups. Such data are needed for making the kind of reliable projections required to plan training programs for specific occupations.

(5) Projections for manpower development program planning require supplementary data: the anticipated number of entrants into the job as well as the turnover rates among various occupations. Such projections would have to take into account such factors as expected changes in wage levels, or other related factors which could induce already trained people to stay on the job or to attract those who have previously quit to return to work. This would raise questions for which, at present, answers can only be guessed.

f. Productivity Measures and Manpower Projections

(Productivity measures vary, depending on the purpose of the analysis and different concepts for expressing output and input.)

(1) Intertemporal analyses of productivity usually compare ratios of output per unit of input over a period of years, whereas interspatial analyses compare productivity ratios between establishments, departments, or other organizations or locations at a given point in time.

(2) Construction of productivity ratios:

Input is expressed in terms of human effort expended (i.e., number of employees or manhours)

Two concepts of output exist:

--Services (activities) performed. These are expressed as the number of completed units or their money values, adjusted for price change.

Physician's fees (deflated for price changes), for example, may be used as a measure of output (Garbarin, PRICE BEHAVIOR AND PRODUCTIVITY IN THE MEDICAL MARKET: Institute of Industrial Relations, U of C, Berkeley, 1960.) The Hospital Administration Service (HAS) of the AMA and the Commission for Administrative Services in Hospitals (CASH) have also used this concept as a basis for measuring productivity.

Employee/patient ratios in hospitals also reflect the "services performed" concept. Since 1946, AHA has annually compiled a series on employee/patient ratios in hospitals, which are useful for analyzing and projecting manpower requirements in the health service industry as a whole. They show the effect of technological and related factors affecting productivity together with changes in the quality of clinical and personal care provided in hospitals. It does not seem possible to separate out their effects in using the ratios.

--Results achieved. Although results will express the achievements of health service establishments (especially with respect to improved quality of care), they are harder to quantify.

(3) A Department of Defense (David Schenker) project to measure productivity in the Armed forces hospitals on the basis of results and services performed, provides figures, per unit of labor input, on "sick days saved" (i.e., effective additional man-days produced) and on the number of cases cured for various disorders.

CONCLUSIONS

1. The primary determinants of future demand for health manpower are the anticipated demand for patient care service and in the kinds of facilities and care needed.

2. Between 1965 and 1975, the general demand for health services will increase. Rising personal incomes, an increased desire for health care on the part of consumers and public authorities (which will lead to higher expenditures for health and continued growth of legislated programs such as Medicare) account for the higher demand.

3. The relative importance of various types of health care facilities and activities will show significant shifts between 1965 and 1975. The importance of outpatient, home care, and nursing home programs will exceed that of inpatient services.

Since a lower labor intensity characterizes services outside the hospital, the overall increase in total employment in health service will be more moderate than would occur if the demand for hospital inpatient services, which are characterized by high labor intensity, expanded equally rapidly.

4. Productivity in the health service industry will improve during the decade 1965-1975.

a. Automation in the clinical laboratory, the use of disposables, and other productivity-promoting innovations should reduce the manhour requirements for hospital care.

b. The general effect of innovations in the health field is primarily to raise the quality of health care, and thus, on the whole, tends to increase the demand for manpower trained in new skills rather than reduce the demand for labor. New kinds of jobs emerge and existing jobs must broaden to incorporate new skills.

Vector Research, Inc., AN INVENTORY OF HEALTH MANPOWER MODELS, prepared for the Bureau of Health Resources Development, U.S. Department of Health, Education, and Welfare, May, 1974.

OBJECTIVE

This study presents an inventory of models directly or peripherally related to health manpower supply and requirements problems that were developed and/or reported during the period 1960 to 1973.

METHODOLOGY

The objective of the study is fulfilled by the development of a health manpower classification scheme and an inventory indexing scheme. Each model is identified by a descriptive title, developer's name and reference. General description includes the status of development, the purpose of the sponsor, the scope and subject, an abstract, major outputs, and assumption/constraints/hypothesis. The technical description includes type of model, model characteristics, data sources, input variables, output variables, verification/applicability/reliability, and computer characteristics of the model. The general criteria for choosing a particular model was to include in the inventory all health process descriptions which analytically define the mathematical relationship between variables directly related to health manpower problems.

CONCLUSIONS

Not applicable.

Walker, Katey, "Factors Affecting the Supply of Labor in Selected Health Care Occupations in a Local Labor Market," unpublished manuscript presented at Western Economic Association Conference, June, 1975.

OBJECTIVE

To identify and analyze the factors affecting the supply of labor in and the requirements for allied health occupations in a local labor market. As an exploratory inquiry, the scope of this study is limited to a detailed study of three occupations: (1) licensed vocational nursing; (2) medical technology; (3) inhalation therapy.

METHODOLOGY

Employing data from the Sacramento labor market area (i.e., Sacramento, Yolo, and Placer Counties in California), the author classifies nominal variables into discrete categories utilizing tests employing the chi-square statistic. The major considerations deal primarily with the supply side of the local labor market. Variables considered include personal characteristics, socio-economic status, cost and availability of information about paramedical occupations, costs and availability of training, licensure and certification, geographic mobility, and occupational mobility.

CONCLUSIONS

Some major conclusions drawn are: (1) because of the lower educational prerequisites and shorter training periods, vocational nursing has drawn more women from lower socio-economic backgrounds; (2) the medical technology occupation is commonly selected by individuals with an interest in science and in detailed work, with less emphasis on relationships with patients; (3) two major constraints to entry into inhalation therapy appear to be in the areas of information and availability of training; and (4) a substantial number of individuals had changed occupations and/or were interested in additional career changes which suggests the lack of advancement opportunities.

Zeckhauser, Richard and Michael Eliastam, "The Productivity Potential of the Physician Assistant," JOURNAL OF HUMAN RESOURCES, Vol. 9, No. 1 (Winter, 1974), pp. 95-116.

OBJECTIVE

This paper develops a production function methodology to estimate the potential contribution of physician assistants in the delivery of medical care in an urban health center.

METHODOLOGY

The authors specify a production function whose arguments are generally physicians and physician assistants. This production function is a constant elasticity of substitution type of production function. The data are developed from an urban health center with eight full-time equivalent internists.

CONCLUSIONS

With the optimal mix of factor inputs and the efficient distribution of task assignments, a physician assistant achieves the productivity of half a physician.

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A METHODOLOGY SURVEY

INTRODUCTION

Manpower resource economists have various tools which can be employed both to describe the present situation and to predict the future. In general, there are two techniques which have been used to forecast future manpower needs. For the purposes of this study, we will divide the two techniques into (a) non-stochastic manpower models and (b) simultaneous equation models. While the review which follows is not exhaustive, it is meant to serve as a baseline for what can be accomplished.[1]

NON-STOCHASTIC MANPOWER MODELS

Non-stochastic manpower models have been widely employed to estimate future supplies and demand for health resources, educational resources, and occupational needs. These models are considered non-stochastic in the sense that they view the underlying economic structure in a static way. The relationships between the variables used in these models are thought to be exact and relatively unchanging. For example, if the present use of dieticians is 1 per 100,000 individuals and population increases by 1 million in the next year, the demand for dieticians is projected as an increase of 10 dieticians.

Generally, there are two major advantages accruing from non-stochastic manpower models. First, they allow almost unlimited disaggregation. For example, the labor category of health services administrator can be further refined to health officer, environmental control administrator, public health administrator, etc.[2] Such disaggregation allows for quite specific estimates of manpower supply and demand. Second, non-stochastic manpower models are straightforward. Such an approach allows for speed of computation as well as eliminating the need for specially trained personnel to perform such computations. This may explain why these models are the most prevalent in allied health manpower literature. In what follows, we consider the major strengths and weaknesses of non-stochastic models.

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[1]It must be noted that all methods considered here have not yet been employed in allied health manpower projections.

[2]For illustrations, see Marland Y. Pennell and David B. Hoover, Health Manpower Source Book 21 (Bethesda: Bureau of Health Professions Education and Manpower Training, 1970), pp. 40-47.

Ratio Methods

The most common and simple method of supply and demand projections makes use of a fixed ratio. Usually the fixed ratio has some relationship to the general population and is sometimes called a "fixed population ratio method." However, the fixed relationship can just as easily consider median age, mortality or even gross national product.

As an illustration, suppose we were to project the future demands for dieticians as noted above. Formally we would determine the present total number of dieticians and the current population. Let d_t represent the former and P_t the latter in the t-th time period. Then in time period t + 1 the future demand for dieticians is given as:

$$(1) \qquad (d_t/P_t)\, P_{t+1}$$

where P_{t+1} is the future population.

While the projection of future population P_{t+1} may employ the most sophisticated forms of analysis, the ratio method still leaves much to be desired. First, future population projections usually do not account for changes in the composition of the population. Specifically, different subsectors of the population clearly have different demands for particular health manpower resources.[3] Clearly, as the composition of the population changes (e.g., a more youthful population), the demands for specific health manpower resources could differ considerably from what is projected in equation (1).

Second, calculations of projections employing the fixed ratio method have difficulty in accounting for changes in health manpower resources productivity. The changing productivity question is especially important when projections are made far into the future.

The question of productivity change gives rise to the issue of medical personnel skill substitutability. The fixed ratio method does not consider relative wages, and hence, does not consider the possibility of one type of health manpower resource substituting for another. In addition, technological change might alter the degree to which particular skills substitute for one another.[4] For example, improved technology in operating room capital may decrease the substitutability between operating room technicians and registered nurses.

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[3] R. Fein, The Doctor Shortage: An Economic Diagnosis (Washington: The Brookings Institution, 1967), attempts to account for differing demands by various socioeconomic groups.

[4] See Gordon H. Kubota, Technological Change and Labor Skills Substitutability: An Econometric Study, unpublished PhD dissertation, Claremont Graduate School, Claremont, California, 1974.

Fourth, the fixed ratio methods say nothing about the adequacy of the medical care itself. In fact, there is almost an implicit assumption that the present ratio represents adequate medical care.

Fifth, there are basically no means of empirically testing this method for either misspecification of relationships or omitted relationships. In terms of planning for the future, these weaknesses may be quite significant.

Professional Standards Approach

The professional standards approach employs the opinions of medical experts in order to determine the requirements needed to treat particular illnesses.[5] For example, instead of using existing doctor/population ratios, these experts estimate the fixed input-output relationship which would provide a standard level of health care. Once this standard is fixed, the incidence of a particular illness is estimated and health care needs are determined. Fundamentally, this type of methodology maintains disease or illness prediction as the central concern while manpower needs become a residual.[6]

From an economic point of view, the professional standards approach is limited. First, such an approach does not consider economically efficient manpower mixes for treatment of illness. For example, a particular illness might be treated with a physician and a registered nurse equally well. The proper choice of manpower mix depends upon the relative costs of the substitute treatment procedures. What the professional standards approach abandons is the possibility of substituting economically efficient manpower mixes as relative wages change.

Second, the professional standards approach gives no consideration to the binding nature of a patient's income. This may be the result of assuming that medical services are income inelastic.

Third, the professional standards approach must necessarily predict future technological advances toward disease eradication. In addition, as particular diseases become more

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[5]This might be considered a quasi Delphi approach. For a full discussion, see B.B. Brown, Delphi Process: A Methodology Used for the Elicitation of Opinions of Experts (Santa Monica: The Rand Corporation, 1968).

[6]For example, see Hyman K. Schonfeld, Jean F. Heston and I.S. Falk, "Numbers of Physicians Required for Primary Medical Care," New England Journal of Medicine, Vol. 286 (March, 1972), pp. 571-576.

prevalent (e.g., venereal disease), these increased incidences must be accounted for by the methodology. Thus, in a sense future manpower requirements, hospital needs, etc., become totally dependent upon the quality of disease prediction.

Vacancy Approach

The manpower literature is filled with the attempts to use job vacancy data. When manpower projections are the central issue, not only current, but future, job vacancies must be considered. Generally, data are collected from employing institutions on present employment, replacement employment, and future employment needs as a result of facility expansion, demand changes, etc. Once this information is obtained, net job stocks in the future are determined. Such a methodology has two major advantages. First, the data can be collected through fairly inexpensive survey methods. Second, there are almost unlimited possibilities for disaggregating the manpower skills categories. In general, the job vacancy methodology is quite straightforward.

From an economic point of view, however, the job vacancy methodology has some severe limitations. First, the projection time period is necessarily short. While budgeted positions for the coming year may be available, longer projections are basically guesses. Second, supply and demand conditions for the medical personnel in question must be stable. If significant changes were to occur, the projected needs could be drastically altered. Third, in order to determine methodological accuracy, follow-up surveys are necessary. This can become a fairly costly procedure.

In addition, this methodology fails to consider some harsh economic realities. First, to preserve accuracy, an indication of inter-institutional manpower migration would be necessary. Second, consideration of participation of individuals not currently in the labor force would be necessary. For example, at increased wage rates, medically skilled individuals not currently in the labor force may be encouraged to reenter.

Finally, there is an inherent bias built into the data sources. Specifically, there could be a tendency for administrators to overstate future needs in order to reap the benefits of increases in future supplies.[7]

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[7]See Robert Ferber and Neil Ford, "The Collection of Job Vacancy Data Within A Labor Turnover Framework," in Arthur M. Ross (ed.), Employment Policy and the Labor Market (Berkeley: University of California Press, 1965), pp. 162-190.

Linear Programming Approach

A form of mathematical optimization, linear programming, has been employed in manpower planning.[8] In general, an objective function is specified (e.g., maximizing doctor contact hours). In addition, multiple constraints which account for the scarcity of inputs are determined. The linear programming optimization determines the most efficient allocation of a given available set of scarce resources.

The most positive feature of the linear programming approach is that usable results are directly obtainable.[9] These results are known to be optimal if a solution exists. In addition, optimal solutions can be achieved considering several methods of combining the scarce resources.[10] Thus, unlike the professional standards method, the linear programming approach is capable of considering various ways for achieving a particular treatment or output.

While a linear programming approach may yield many insights for the health manpower planner, it does not generally address the issue of predicting future manpower needs. This is the result of the static nature of the modeling. With fixed technological relationships, future needs can only be projected in terms of alternative scenarios. While a great deal of work is currently addressing this limitation, the results have not been highly fruitful.[11]

ECONOMETRIC MODELS

Econometric models have been used to determine manpower requirements for various skills categories.[12] The null

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[8]For a generalized manpower model, see Samuel Bowles, Planning Educational Systems for Economic Growth (Cambridge: Harvard University Press, 1969).

[9]Robert Fetter and Ronald E. Mills, "A Language to Aid in Manpower Planning," DHEW, Public Health Service, 1972.

[10]K.R. Smith, M. Miller, and F. Gollady, "An Analysis of the Optimal Use of Inputs in the Production of Medical Service," Journal of Human Resources, Vol. 7, No. 2 (Spring, 1972), pp. 208-225.

[11]See Gordon H. Kubota, "Labor Skills Substitutability: A Linear Programming Approach," an unpublished paper presented to the Faculty of the University of California, Riverside, March, 1975.

[12]For examples, Lee Benham, "The Labor Market for Registered Nurses: A Three-Equation Model," Review of Economics and Statistics, Vol. 53 (August, 1971), pp. 246-252; M.S. Feldstein, "An Econometric Model of the Medical Care System," Quarterly Journal of Economics, Vol. 85, No. 1 (February, 1971). pp. 1-20.

hypothesis, under which an econometric model is constructed, is accepted economic theory.[13] The econometric structure attempts to explain economic phenomena. In addition, the estimated model may be used to predict future outcomes. This facet of an econometric model provides the opportunity to construct various scenarios from which policy implications might be drawn. Thus, an econometric model facilitates both explanation and forecast.

The variables used in an econometric model fall into two categories. Endogenous variables are those which the model purports to explain. Specifically, the values of the endogenous variables are generated from within the model structure itself. Alternatively, exogenous variables are those which are predetermined in the modeling system. In this sense, they are independent, explanatory, and casual.

Econometric models assume that the real world is complex and interdependent. This leads to the need to model simultaneous equation systems which require fairly sophisticated approaches to statistical tests of validity.[14] The ability to compare predicted with actual results and to make tests of statistical significance is the greatest attribute of econometric modeling techniques.

The critics of econometric modeling cite several faults when the technique is applied to the health manpower area.[15] In general, these criticisms attack econometric modeling techniques for the wrong reasons.

The first criticism of econometric modeling techniques is that many equations must be specified, and many observations collected to insure that there is no degree of freedom shortage. In general, the greater the number of equations specified and the greater the number of variables used, the fewer the degree of freedom available for statistical tests. The true issue here is how much the econometric model disaggregates economic behavior while concurrently maintaining a simultaneous equation

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[13]Carl Christ, Econometric Models and Methods (New York: John Wiley, 1966), p. 7.

[14]See Lawrence Klein, A Textbook of Econometrics (Englewood Cliffs; Prentice-Hall, 1974), pp. 131-194.

[15]See Marsha G. Goldfarb, "Critique of Health Manpower Literature," Working Paper Series, No. 73-2, Yale University School of Medicine, 1973.

structure. The criticism would be valid if the detractors had argued that econometric models have difficulty maintaining both a highly disaggregate view and a strict simultaneous equations specification. If, however, some aspects of the economic phenomenon under consideration are separable, this criticism generally loses force. In addition, if the economic phenomenon occurs in a particular way (e.g., in a recursive fashion), the problem of degrees of freedom presents little concern.[16]

A second criticism argues that econometric models might use the parameters of cross section estimation to predict time series forecasts. For example, it has been argued that comparing the parameters of a 1967 cross sectional analysis of RN wages would yield different parameter estimates than those estimated using time series data.[17] Thus, econometrics has a problem distinguishing time series and cross section estimation. This criticism clearly indicates lack of understanding of econometric techniques. First, we can think of no illustrations in the econometric literature where cross sectional parameter estimates were employed to forecast into the future. Second, the two forms of data collection are not altogether divorced since aggregate cross sections in each year might provide a consistent time series in itself. Finally, the estimation of time series-cross section models exists.[18] Specifically, these models employ the disaggregate information of a cross section as well as the aggregate information of a time series. On the whole, this criticism of econometric techniques is unfounded.

A third criticism is that economic theory often suggests complex mathematical forms for the structural econometric equations and that these complex forms make statistical estimation intractable. This criticism, in essence, argues that the modeling of complex phenomena be abandoned. In addition, it fails to consider recent gains made in econometric estimation, such as the ability to estimate models in disequilibrium, new maximum likelihood techniques, flexible functional forms, etc. In reality, modeling complex relationships is much more difficult than estimating such structures. This problem would serve as a more valid criticism of the econometric methodology.

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[16]See J. Johnston, Econometric Methods (New York: McGraw-Hill, 1972), pp. 377-380; Klein, op. cit., pp. 197-202.

[17]Goldfarb, op. cit., p. 34.

[18]See Christ, op. cit., pp. 233-238.

SUMMARY

While each methodology considered above has inherent problems, the fact remains that manpower predictions in allied health fields are essential. Useful predictions should aid in

- improvement of the quality of allied health personnel in the future
- specification of guidelines for underwriting the cost of training
- determination of the training mix of various colleges and universities
- improvement in specifying future training budgets
- improvement of employment counseling and testing services to help individual job-seekers make intelligent occupational choices.

In short, it is the contention of this study that the gains from recognition of future manpower needs far outweigh the cost or inherent problems of making such predictions.

SURVEY OF EXPERTS

To aid in the theoretical economic modeling, experts in specified allied health manpower categories were consulted. A brief questionnaire was administered at the CSUC Health Manpower Conference on March 12, 1976.

The questionnaire was designed to elicit answers regarding skill substitutability, skill migration, capacity limitations, representative profiles of recent graduates, and special issues for each of seven allied health categories. The questionnaire follows, along with a summary of the responses obtained. In addition a speech given at the March 12 conference is included. Its purpose was to delineate the methods of projection to be employed in the study and to answer questions regarding these methods.

Questionnaire for Allied Health Manpower Project

Please circle the allied health manpower category for which your expertise is greatest. This questionnaire is meant for the category you have circled.

Medical Technology	Occupational Therapy
Physical Therapy	Health Services Administration
Environmental Health	Speech Pathology and Audiology
	Dietetic and Nutritional Services

1. Of all possible health manpower categories, which has the greatest skill substitutability to the circled category? _____. What is the percentage of overlap?_____.

2. In terms of the occupations listed above, which has the greatest skill substitutability to the circled category? _____. What is the percentage of overlap? _____.

3. Addressing Question No. 2, what is the percentage of curriculum overlap (i.e. duplicated or shared courses) between the two categories?_____.

4. Considering the circled skill category, what % of the curriculum overlap occurs with the general student body of your institution?_____.

5. Of all faculty directly associated with allied health manpower programs, what percentage teach only in the circled category?_____. What percentage can teach in two or more categories?_____.

6. Of all faculty directly associated with health manpower, what percentage require licensing?_____.

7. Considering the circled category, what percentage of your graduates remain in California?_____. What percentage of those remaining in California eventually find employment here?_____.

8. Of all individuals qualified in the circled skill category in California, what percentage would you say are actively working in that skill?_____.

9. Addressing Question No. 2, how many quarter units would be required for an individual to switch from the circled category to the noted category?_____.

10. In percentage terms, to what extent could the student body in the circled category be increased without increasing your institution's training capacity?_____.

11. If licensing or certification is required for the circled category, is it renewable?_____. Does it require continuing education?_____. Are there client or work experience requirements?_____. Would out of state certification be generally acceptable? _____.

12. In terms of the circled category, what percentage of your graduates would you expect to find employment in this skill within one year?_____. What percentage would you expect to find employment within 1 to 3 years after graduation?_____.

13. Have technological innovations changed the skill requirements of the circled category in the last five years? _____. If so, how many quarter units of training would equate the skills of a 1970 graduate to a 1976 graduate?_____.

14. Is the training of the circled category dependent upon an ancillary program (e.g. hospital internship)?_____ _____. If so, what percentage of capacity would you estimate these ancillary programs to be?_____. What would be the representative ancillary program?_____ _____.

15. For the representative (average) recent graduate in the circled category, please categorize by the following:

Age_____

Sex_____

Time for program completion (years and months)_____

Minor (if any)_____

Probability of continuing in a higher degree program_____ _____

Final location in miles from school_____

Type of employer (hospital, clinic, etc.)_____

Percent of educational costs scholarshipped_____

Starting salary_____

SUMMARY OF ECONOMETRIC MODELING QUESTIONNAIRE

This is a brief summary of the findings of a questionnaire administered at the CSUC Health Manpower Conference of March 12, 1976. No sample sizes were large enough to make arguments for statistical validity. (However, the findings help to increase understanding of the seven allied health manpower fields and may help improve econometric modeling.) In this sense, the results are quite useful.

There is inherently different quality in the responses, due primarily to the use of a single questionnaire for all seven categories of allied health considered. However, many economic issues directly addressed will facilitate proper econometric modeling. For example, constraining capacity limitations seem to be holding in speech pathology and audiology but not in the field of environmental health. The econometric modeling will treat capacity limitations differently in the two fields. The lack of response in some fields signals the need for further investigation before modeling can be attempted.

DIETETIC AND NUTRITIONAL SERVICES

These results are based on a sample size of four, with fairly substantial completion of the questionnaire and reasonably consistent answers.

Substitutability

The mentioned areas of substitutability in skills were medical technology and health services administration. The overlap seems to be 25-30%. In terms of curriculum, 35% overlap occurs within the mentioned allied health fields and 30% overlap occurs within the general student body. Switching from this allied health field to the noted ones would require approximately 75 quarter units. Registration, but not necessarily licensing, seems to be needed. Nothing can be said regarding faculty registration or licensing.

Skill Migration

Approximately 65% of the graduates remain in California. Of those, 86% eventually find employment. Approximately 80% are actively working in their trained field.

Special Issues

Registration seems to be renewable, with some sort of work experience necessary. Continuing education is required. Out of state registration seems to be adequate.

Approximately 71% of these individuals find work within one year. 93% are thought to find work in the 1-3 year range. There may be hints of slack in this profession.

All respondents agreed technological change was occurring. However, only 8 units were thought to be necessary to equate a 1970 graduate to a 1976 graduate.

Capacity Limitations

There seems to be excess capacity in the training institutions of approximately 42%. The ancillary programs tied to hospitals are at capacity for training purposes.

Representative Profile

The representative member of this profession at graduation is a 22-year-old female. Low scholarshipping occurs in the 4.5 years needed for completion. There was unanimous agreement that minors were not taken. However, the probability of advancing to a higher degree program was .65. This individual works

for a hospital within 150 miles of the training institution at a starting salary of $11,000.

Problems

There are signs of insufficient demand and low technological change.

ENVIRONMENTAL HEALTH

These results are based on a sample size of five. The questionnaires were fairly complete. An obvious effort was made by the respondents to give as much information as possible.

Substitutability

Possible areas of general substitutability for environmental health include medical technology, microbiology, occupational safety, and health services administration. The overlap is thought to be about 42%. In terms of the listed areas, medical technology and health services administration were mentioned with an overlap of 24%.

In terms of curriculum, there seems to be a 25% overlap with the mentioned allied health fields and an 11% overlap with the general student body. Instructors are registered rather than licensed. 30% of the instructors teach only in environmental health with 34% capable of teaching in two or more areas. Switching to the mentioned allied health fields would require approximately 63 quarter units.

Special Issues

The registration in this field is renewable. Out of state credentials are generally not acceptable. There seems to be no current continuing education in this profession. Client or work experience issues are inconclusive.

There may be a discouraged worker effect here. Only 64% of the graduates are expected to find work within one year. 83% would find work in the 1-3 year period.

Technological change is occurring in this field. It is estimated that 14 quarter units would be required to equate a 1970 graduate to a 1976 graduate.

Capacity Limitations

An institutional capacity constraint is not binding. It was estimated that a 20% increase in graduates could be provided without increases in capacity. The ancillary program, usually with a local public health unit, was at only 80% capacity.

Representative Profile

Environmental health is represented by a 24-year-old male graduate who took approximately four years to complete

his education. His minor could be in biology or administration. He was most likely not scholarshipped (less than 5% are). His probability of continuing for a higher degree is estimated to be .46. This individual would work for a public health department located within 55 miles of his training center. His salary is estimated to begin at $12,080.

HEALTH SERVICES ADMINISTRATION

These results are based on a sample size of seven. Only four questionnaires were completed in full.

Substitutability

The professions noted as the closest overall substitutes were hospital administration, environmental health, business administration, and "none." The average percentage overlap was given as 31%. In terms of the listed categories, environmental health and medical technology were noted. The average overlap was given as 11%.

Curriculum overlap within the noted fields was given as 11% while curriculum overlap with the general student body was 18%. Only 11.7% of the instructors teach in this field exclusively. Approximately 21 quarter units would be required to make a switch within the two noted categories.

Skill Migration

Approximately 90% of this category find work in California. Of California health services administrators, 87.8% are thought to be actively working in this field.

Special Issues

It seems that licensing and/or certification does not generally occur. Since 92.5% and 96.5% of these individuals are thought to find employment within a year and within 1-3 years respectively, the discouraged worker hypothesis may not hold. The price associated with upgrading the 1970 graduate to 1976 seems to approximate 15 quarter units, based on technological changes.

Capacity Limitations

The training of this skill might be increased 47.8% within the capacity of current institutions. Ancillary programs are used to only 15% of capacity.

Representative Profile

The health services administrator is characterized as a male, 29 years old. He completes his program in 3.2 years with possible minors in allied health, business, biology, and medical technology. The probability of continuing into a higher degree program is .25. Less than 4% scholarshipping occurs. This individual is likely to be employed within 100 miles of his school and to be working for a hospital or clinic. His starting salary is approximately $13,000.

MEDICAL TECHNOLOGY

These results are based on a sample size of nine. The questionnaires were fairly complete.

Substitutability

In general, there seems to be some substitutability between medical technologists and other skills. Of all possible health manpower categories, microbiologists, environmental health personnel, and clinical chemists were mentioned. The skill overlap was approximated at 45%. Of the specified fields, the closest substitute seems to be dieticians and environmentalists with a 14% overlap. The price of switching disciplines is approximately 63 quarter units.

In terms of curriculum, it was estimated that 22% overlap occurred with other allied health fields and a 37.5% overlap with the general student body. Generally, instructors do not teach in only this field. 55.7% teach in multiple disciplines. Faculty licensing is approximately 37.8%.

Skill Migration

The migration issue in this field could be very important. While 91% of the graduates remain in California, 89.4% find employment here. The total actively working in this skill is estimated to be 68%, which provides a potential skills pool.

Special Issues

The licensing issue was not solved by the results of the questionnaire. There does not seem to be any tendency for continuing education in this field.

A case might be made for the discouraged worker hypothesis. While 90% find employment within one year, only 76% are thought to find employment in the 1-3 year category. These figures seem to be consistent with the low participation rate.

Technological innovations are occurring in this field. A 1970 graduate could be equated with a 1976 graduate with approximately 12 quarter units of work.

Capacity Limitations

There was almost unanimous agreement that the capacity for training is presently fully utilized. However, the question of ancillary program capacity was estimated at only 60%.

Representative Profile

The representative medical technologist is a female approximately 23 years old upon graduation. The time for graduation is thought to be 4.5 years. Less than 5% of the students are scholarshipped. Normal minors include chemistry and biology if any are taken. Most members of the profession seem to be employed by hospitals or clinics at a starting salary of $11,200, within 120 miles of the training institution.

OCCUPATIONAL THERAPY

The results are based on a sample size of four. Since the questionnaires were incomplete, only tendencies are reported.

Substitutability

The field with the greatest overlap seems to be physical therapy (10-12%). Other substitution questions were inconclusive.

Skill Migration

While approximately 86% of the graduates are thought to remain in California, the employment question generally was unanswered. However, it was thought that 72% of those trained in this field were still actively working.

Special Issues

Renewable licensing occurs in this profession. No client work and no continuing education seem to be necessary. The out of state licensing issue was not determined. The discouraged worker question was not answered. All that can be said is that technological change is thought to be occurring.

Capacity Limitations

Oddly enough, all respondents argued that no increase in student output could be achieved within the current institutional structure. While ancillary programs exist, no determination of their capacity was noted.

Representative Profile

Little can be said about the representative individual in this profession. The individual is thought to be a 23-year-old female who works for a "community agency." The probability of continuing education seems to be less than 10%. Other issues were not addressed.

Problem

Very little usable information.

PHYSICAL THERAPY

These results are based on a sample size of three. Since the questionnaires were incomplete, many issues do not reflect even minor tendencies.

Substitutability

The closest field seems to be occupational therapy with a 15% overlap of skills. Additionally, physical therapy overlaps 26% in curriculum with the noted allied health occupations and 18% with the general student body. Switching from physical therapy to its near substitute would require 60 quarter units. Little can be said in terms of faculty.

Special Issues

Licensing/certification is generally renewable, with client work necessary. There does not seem to be a need for continuing education. Out of state licensing is regarded as acceptable.

Virtually all graduates are thought to find employment within one year.

While technological change is occurring, only 7 units are necessary to equate a 1970 and 1976 graduate.

Capacity Limitations

Less than a 5% increase in graduates seems possible within existing capacity. Since ancillary programs in hospitals are a must, their 95% capacity seems to be a binding constraint.

Representative Profile

This representative profile is highly inconclusive. The graduating physical therapist is thought to be a 22-year-old female. Completion requires 21 months without a minor. Scholarships are nonexistent. The individual locates within 25-100 miles of the training institution and works for a hospital at a starting salary of $13,800.

Problem

More information is necessary before modeling can be attempted.

SPEECH PATHOLOGY AND AUDIOLOGY

These results are based on a sample size of six. The questionnaires were fairly complete.

Substitutability

In general, there is little substitutability in this skill category. The closest substitute seems to be a specialized physician. The overlap is thought to be 15%. There is little or no substitutability with the other six health manpower areas. The curriculum overlap approximates only 7% with the general student body. The price of switching to another field requires virtually the entire program of 90-120 quarter units.

The instructors in this field teach only in this area (86%), although 15% are capable of teaching in other areas as well. Licensing is required of approximately 90% of the faculty, although a faculty-exempt status was noted. It seems most faculty have multiple forms of certification.

Skill Migration

Approximately 90% of the graduates remain in California with 97.8% of those finding employment here. Of the trained skill pool, 80.4% are thought to be actively working.

Special Issues

Licensing seems to be required, and is generally renewable. Continuing education seems to occur, and work experience is necessary. The licensing procedure between states is dependent upon the state in question, type of degree, etc.

The discouraged worker hypothesis is not supported since 98.3% find employment within one year and virtually 100% within 1-3 years.

Technological change seems to be a fairly strong issue here. It is estimated that 26 quarter units would be required to equate the skills of a 1970 graduate with the skills of a 1976 graduate.

Capacity Limitations

It seems that little increase in this field can occur without capacity increases. Only 3% increase is possible within the existing structure. Ancillary programs are thought to be at 47% of capacity.

Representative Profile

The speech pathologist and audiologist is characterized as a 23-year-old female. Scholarships are less than 5% for students in this field. The average completion time is thought to be 4.6 years, and virtually all new graduates must attain a master's degree. Possible minors for this specialty include psychology and speech education. The largest single employer remains the public school system. The starting salary is approximately $10,500.

Problems

These data are not consistent with age-sex profiles of females in the work force. They have a very high labor force participation rate if our data are reliable. In addition, average salary does not seem consistent with levels of employment and educational requirements.

HEALTH MANPOWER CONFERENCE ADDRESS: MARCH 12, 1976

Dr. Gordon Kubota

INTRODUCTION

The national goal of improving the health of Americans has made health care one of the fastest growing sectors in the U.S. Economy; rising disposable income, population growth, expanded health insurance, and government financing of health care have all contributed to a significant increase in the demand for health services. Despite massive growth in the general level of employment, manpower in many health care occupations has fallen short of needs.

Conceptually, the structure of health care manpower resembles a pyramid. This pyramid consists of three basic levels. The top of the pyramid represents the highly trained and educated personnel such as physicians and dentists. These individuals represent one of every seven health care workers. The middle of the pyramid represents highly trained allied health workers such as registered nurses, medical technologists, etc. Two of every seven health workers belong to this middle portion of the health manpower pyramid. Finally, the base of the pyramid is composed of those individuals whose occupational skill levels and training are somewhat less than their mid-level counterparts.

In general, the focus of our concerns is on a subset of the mid-level of the health manpower pyramid. In particular, the occupations categorized as:

Medical Technology
Occupational Therapy
Dietetic and Nutritional Services
Physical Therapy
Health Services Administration
Environmental Health
Speech Pathology
Audiology

are direct concerns for our research. However, like the pyramid itself, these professions do not exist in a void divorced of the top nor divorced of the base.

How are our concerns manifested? The exact goal of our portion of the study is to predict the manpower needs of these selected categories of allied health professions annually through 1979. These projections are designed to fit into a framework...

a framework designed to produce projections of health manpower whose principal responsibility is to directly provide health care. It is our responsibility to be fully aware of the economic phenomena which can drastically alter the quality of our predictive efforts.

Illustrative Allied Health Manpower Projections

In 1972, the then Bureau of Health Manpower Education ordered its Division of Manpower Intelligence to assume the responsibility of providing information and analyses that could be used in developing alternative strategies for the education of health manpower. This effort, called Project SOAR (Supply, Output, and Requirements), was designed to assess the present situation as well as what might be expected in the years ahead.

In terms of the allied health manpower categories we are considering, the SOAR model provides the following predictions for the United States:

Occupation	Number of Active Formally-Trained Personnel			Percent Change	
	1970	1980	1990	1970-80	1980-90
Dieticians	15300	18170	22340	18.8	23.0
Medical Technologists	45000	80620	123520	79.2	53.3
Occupational Therapists	7300	11760	16880	61.1	43.6
Physical Therapists	11550	23030	36570	99.4	58.8
Speech Pathologist and Audiologists	13300	37070	70930	178.8	91.4

Source: Division of Manpower Intelligence, The Supply of Health Manpower, U.S. Department of Health, Education and Welfare, February, 1974, p. 238.

These estimates are for formally-trained personnel only. Consequently, they should not be viewed as representing total active supply. However, these figures do serve to illustrate the type of information which should be available for health education manpower planning.

METHODOLOGY

Unfortunately for the economics profession, these predictions do not materialize as "manna from heaven." Unlike the world of

theoretical economics which can retreat to its CETERIS PARIBUS (all other things equal) assumption, the world of applied economic research fundamentally must grapple with one central issue--Is the product of the research useful? The value of the research is ultimately tied to the methodology employed. It is to this methodology which I now turn.

As the literature would indicate, there is an entire spectrum of methodology which will produce manpower projections for the allied health manpower professions under study. This rainbow of methodologies differs in sophistication, reliability, and usefulness. Without attempting to be exhaustive, we have considered (1) commonly employed ratio projections, (2) a professional standards approach, (3) a traditional job vacancy methodology, (4) a relatively new linear programming approach, and (5) an econometric approach. Of course, each method is complete with its list of pros and cons. Without debating the attributes of each methodology here, it is sufficient to note that we have chosen to make our predictions using a modified ratio approach and an econometric approach. In both instances, we rely on the tenets of received economic theory as our foundation.

MODIFIED RATIO METHOD

In assessing the allied health manpower needs to 1976, the ratio method is quite straightforward. For example, if the present use of dieticians is 1 per 100,000 individuals and the projected population increase is 1 million, the projected demand for dieticians is simply 10 more. While this might seem like a viable approach, it fails to adhere to one of the major caveats from Marshallian economics. Roughly translated, this axiom warns the tailor (in this case the economist) not to attempt to cut cloth with only one-half of a scissor. Specifically, viewing only supply conditions or only demand conditions could result in an uncut suit when manpower forecasts are made.

In order to join the scissors and make the suit, we have attempted to consider issues on both the demand and supply side. On the demand side, we have considered three major issues: (1) population composition, (2) relative prices, and (3) income. In terms of population composition, we are attempting to assess the demands for these allied health manpower categories in light of differing demands by subpopulations. For example, women have a tendency to demand more medical services than do men; the very old and the very young have higher demands than their middle-aged counterparts. Since future population composition for half a decade is quite predictable, we plan to adjust our predictions accordingly. Second, the relative price structure will certainly not remain constant.

Unfortunately, we are not yet in a position to conceptually report how this issue can be resolved in our modified ratio forecasts. Finally, the single most important characteristic affecting the demand for these professionals is family income. We are unwilling to project future demands without some modification for projected family income in California.

On the supply side, we address three major issues: (1) changing productivity of medical resources, (2) the possibility of substituting one type of medical personnel for another and (3) migration. In terms of the productivity issue, we plan to alter future supplies by some standard notion of productivity change in terms of the labor input to health care. To date, these measures have been relatively crude but none-the-less revealing. The skill substitutability issue is most often addressed in terms of relative wages. If there is a tendency for relative wages of fairly like skills to change, substitutions should occur. It seems reasonable to alter our projections where such changes are foreseen. Finally, we would like to address the migration issue from two points of view. The physical migration of these health professionals into or out of California or within the State itself, is an obvious supply alteration. In addition, we are attempting to address the issue of migration into and out of the professions themselves. We are particularly concerned with the possibility of large reserves of professionals currently out of the labor force. If such a pool exists, then we need to modify our projections accordingly. At this stage of analysis, we are adequately convinced that this added sophistication will produce more reliable results than its simpler counterparts.

Before passing on to our econometric methodology, I must be honest and address the issues for which our modified ratio technique is inadequate. First, there is virtually little chance that misspecification of the relationships or ommitted relationships will be discovered. Second, we will have little to say about statistical reliability in terms of our modified ratio method. Finally, our modified ratio methodology cannot address the issue of medical care adequacy.

On the positive side of the ledger, we can insure that predictions for each of the seven major categories can be made with the proper level of dissaggregation. Second, since this approach is straightforward, it lends itself to speed in computation. In addition, these computations do not require specialized skills (such as an econometrician) to be maintained by the using agency. This summarizes the issues, the pros and cons of our modified ratio methodology.

ECONOMETRIC METHOD

Econometric models have been used to determine manpower requirements for various skill categories. The underlying

basis of an econometric model is accepted economic theory. In this sense, the econometric structure attempts to explain economic phenomena. In addition, the econometric model may be used to predict future outcomes. This facet of an econometric methodology provides the opportunity of constructing various scenarios from which policy implications might be drawn. Thus, an econometric methodology facilitates both an explanation of how things are and predictions of how things will be.

A question of concern is: "Why have we chosen to use an econometric methodology over all the aforementioned methodologies?" The answer to this question is many sided. First, unlike the other methodologies, econometrics inherently considers statistical validity. For example, if we predict that the number of occupational therapists needed in California for 1979 represents a 30 percent increase, we would like to know how reliable our estimates are. There is a considerable difference between 90 percent confidence and 40 percent confidence in our predictions. Econometrics addresses this issue explicitly. It may be the most significant attribute of this methodology.

Second, in the world around us events occur simultaneously. The staffing of allied health professions is interdependent with the staffing of physicians as well as the staffing of less skilled health workers. These interdependencies are especially crucial to the validity of predictive results. Without accounting for these interdependencies, a severe bias may result in our predictions, as forecasters of Southern California engineering manpower have found. An econometric methodology handles this issue explicitly.

Third, the econometric method properly sets the stage for handling "if-then" issues. Specifically, an estimated econometric structure is capable of handling hypothetical situations and yields conditional predictions of outcomes. For example, if disposable income were to increase at a 3 percent rate then the projected needs for speech therapists would increase at 12 percent. Other scenarios are possible by changing the "if" conditions, i.e., 5 percent, 10 percent, etc. In addition, the econometric method allows computer automation. Thus, the using agency can exercise its own options directly.

Fourth, an econometric methodology can explicitly consider disequilibrium. What does this mean in terms of allied health manpower? A convincing argument which we have heard repeatedly is that issues other than wages alone allocate allied health manpower. Variables such as licensing, government educational subsidization, collusive agreements, etc., directly influence how health manpower is allocated. Recent theoretical econometric breakthroughs have allowed econometric methods to explicitly consider these types of disequilibria.

Therefore, the statistical verification, the accounting for interdependencies, the handling of hypothetical situations, and the explicit treatment of non-wage rationing have adequately convinced us that an econometric approach is viable.

At this point, there are some of you who think that I am encouraging the use of an "all purpose" tool of analysis. I assure you that if what we are developing were an "all purpose" tool, I would own options on beach property in La Jolla.

The major limitations of econometrics are two-fold. First, if we want a viable econometric model, we need to understand the underlying institutions and issues related to the allied health professions we are considering. This is the predominant theme of our questionnaire. While some of the questions we ask may seem unimportant to you, they may be extremely important to us in developing as realistic a model as possible. In essence, we are asking for your expert advice in order to insure that the tone and direction of our modeling will lead to a useful end product.

Second, the need for quality data is apparent. In a sense, the immediate usefulness of econometric predictions (as is true with all forecasts) is data dependent. When the quantity and quality of data are limited, the econometric methodology personifies an old economic axiom: TINSTAAFL--THERE IS NO SUCH THING AS A FREE LUNCH. When quality data are not available, the econometric methodology must limit the kinds of issues which it can address. This, then becomes the trade-off.

MODIFIED RATIO APPROACH

Traditionally, the most widely-used methodological approach to estimating health manpower requirements is the ratio method. Usually these projections employ a fixed ratio between a specific health manpower category and the population. Because of difficulties imposed by employing a simple ratio method, the procedure used here employs modifying techniques.

A major tenet of Marshallian economics warns the economist not to consider only supply or only demand. Since the ratio method in its simplest form considers neither side of the market picture adequately, some modification is necessary to achieve useful results.

Demand

On the demand side of the health manpower picture, desirable modifications require that attention be given to: (1) the composition of the population; (2) relative prices; and (3) income. The first of these issues leads to consideration of differing demands by particular subpopulation categories. For example, women have a tendency to demand more medical services than do men; the very old and the very young have higher demands than their middle-aged counterparts. Thus, some attention needs to be given to age composition in assessing future manpower needs.

Second, over time the relative price structure cannot be expected to remain constant. If the cost of medical care provided by the allied health professions under consideration increases disproportionately with other goods and services, distortions will be perceived in terms of the ratio projections. Hence, the relative prices of these types of medical care should be considered.

Third, any projection of allied health care which does not consider the demander's income is somewhat suspect. From an economic point of view, use of the specified set of allied health manpower professionals is not divorced from the income constraints imposed on the demanders. For example, the medically essential use of an occupational therapist may be well outside the income abilities of those individuals who might benefit from these skills. Therefore, it seems reasonable to adjust the ratio projections in order to account for income levels.

While modifying the ratio method to account for changing population composition, relative prices, and income does not exhaust the set of demand influences which might cause distortion

in the projections, it is felt that addressing these major issues will alleviate the bulk of the demand-related problems. In addition, directly addressing these demand issues should improve the reliability of the projections.

Supply

On the supply side, desirable modification of the simple fixed ratio method requires that attention be given to: (1) the changing productivity of medical resources; (2) the possibility of substituting one skill category for another, and (3) migration.

First, the issue of productivity is crucial in the projection of allied health manpower needs. As is the case with other labor resources, the skills under consideration are subject to alterations in productivity. For example, sophisticated electronic capital seems to have substantially altered the productivity of audiologists. If productivity advance is not accounted for properly, estimates of future manpower requirements might be overstated.

Second, there is always the possibility of one labor skill substituting for another when many of the skills of a particular occupational category overlap with other categories. Economists generally measure the degree of substitutability between inputs with an elasticity of substitution: the greater the elasticity of substitution, the greater the ability of one input to substitute for another. Of course, the empirical criteria for substitutability depend heavily on the relative wages of the inputs in question. Thus, projections of future manpower needs which do not account for skill substitutability may result in clear overstatements if relative wages change.

A third supply alteration occurs concerning health professionals in two types of migration: (1) into and out of the State of California; and (2) into and out of the profession itself. Migration patterns into and out of the state represent a relatively standard issue in manpower economics. However, the issue of migration into and out of the profession itself is not commonly addressed. (The possibility of large reserves of qualified professionals who may be enticed into the labor market under favorable conditions is not of concern here.)

In summary, it would seem that these supply modifications would increase the accuracy of the projections. While these modifications are not meant to be exhaustive, they should serve to account for a large percentage of the distortions which might have occurred had no attention been given them.

Basic Model

Before developing the modification presented above, it seems reasonable to specify the basic unaltered structure of the ratio method. The health manpower/population ratio method is undoubtedly the most common of the possible ratio methods. It is employed to characterize the current manpower situation, to assess the adequacy of present occupational skills, and to determine the number of personnel that will be required to provide health services in the future.

The assumption underlying the ratio method is that the population size is the major determinant of future manpower requirements. Thus, the essential data requirements for the application of the method are future population projections and a specified ratio. In its simplest form:

(1) manpower requirements = population x specified ratio. Current requirements are calculated by multiplying present population by the specified ratio; future requirements are calculated by multiplying projected population by the designated ratio. In addition, the adequacy of present occupational manpower can be assessed by comparing the ratio of present manpower to population with some predetermined specified ratio, e.g., a ratio set by a professional standards approach.

When the ratio method is employed, the tacit assumption is that changes in the size of the population will require a proportional change in health personnel. In short, the argument is employed that the health care professions are so structured that population growth produces a proportionate increase in the demand for services. In addition, it is assumed that a proportional change in the specified manpower category will exactly match the changing demand of the projected population. In light of the criticisms noted in the previous chapter, these manpower/population ratio projections can be viewed only as a baseline to which modified estimates are compared and analyzed.

Empirical Results: The Basic Model

In order to obtain manpower estimates using the basic model, two techniques were employed. First, the specified ratio was determined for each of the seven skill categories employed by simply dividing the California health manpower category by California civilian population. Allowing to represent this ratio for the skill category,

(2) $d_i = \frac{\text{number in } i^{th} \text{ skill category in year}}{\text{California population}}$

Since forecasts of the future are the prime concern, the most recent available manpower figures were employed. Table 1 summarizes the computed ratios. (The ratios for medical technologists and environmental health workers, because of questionable data, are based on U.S. figures. The lack of data for health administration forced the use of U.S. Department of Labor projections. However, these projections tend to agree with the initial developments by the California Hospital Facilities Commission's recent survey. Unfortunately, the Commission's data are not yet available.)

TABLE 1

Allied Health Manpower/Population Ratios

CATEGORY	d_i	time period used to obtain ratio
Medical Technology	0.0004677[a]	1975
Occupational Therapy	0.0001032[b]	1975
Dietetic & Nutritional Svs.	0.0001484[c]	1975
Physical Therapy	0.0000842[f]	1973
Health Administration	0.0006810[d]	1975
Environmental Health	0.0000648[e]	1973
Speech Pathology & Audiology	0.0000885[f]	1972

[a]Based on letter from the American Society of Clinical Pathologists, May 25, 1976.

[b]Based on letter from the American Occupational Therapy Association, May 25, 1976.

[c]Based on letter from California Dietetic Association, May 21, 1976.

[d]Based on U.S. Department of Labor, Bureau of Labor Statistics projections for 1975.

[e]Based on National Data.

[f]Health Resources Statistics, 1974.

The second technique required to obtain allied health manpower projections is some sort of future population projection for the State of California. While it is possible to make use of California State Department of Finance population projections, these projections are not made on an annual basis. Thus, for the present purpose, it was necessary to develop a model which would project California population on an annual basis. The model which yielded the "best fit" was one in which:

(3) CALPOP = f(DENSE, NET, NATURAL, LOSS, TIME) where
CALPOP= California Civilian Population
DENSE = ratio of California Civilian Population to U.S. Population
NET = Net California Migration
NATURAL= Natural increase in California population
LOSS = California Net Loss to the Military
TIME = Time

Employing time series data from 1945 to 1975, equation (3) was fitted in linear form. The estimated equation is given as:

(4) CALPOP = -5160.76 + 212236.22 DENSE - 1.7077 NET
(27.09) (-7.33)
+ .962 NATURAL - 0.0040 LOSS + 159.902 TIME
(1.40) (-0.02) (14.85)
Adjusted R^2 = 0.99958
F = 14526.38
DW = 1.067

Students' statistics are presented in the parentheses under the estimated coefficients. The coefficient of determination (R^2) is reported along with the F statistic and Durbin-Watson statistic, i.e., DW.

Equation (4) was employed in making population projections for 1976 to 1980. The largest errors in the 1945 to 1975 predictions amounted to 1.0% in 1954 and 1.1% in 1955. All other errors were less than 1%.

Table 2 summarizes these projections. These population projections are based on the continued change in the density variable and time. Net migration, natural increase, and loss to military are assumed to have remained at 1975 levels. In this sense, the projected population may be somewhat conservative.

TABLE 2

California Population Projections: 1976 - 1980

	1976	1977	1978	1979	1980
Expected Population	21022819	21267616	21512413	21757211	22002008
Below	20940808	21185605	21430402	21675200	21919997
Above	21104830	21349627	21594424	21839222	22084019

The first row of Table 2 presents the estimates of California population using equation (4). The second row presents California population projections one standard deviation below the forecasted level. The last row presents forecasts one standard deviation above the forecasted level. Thus, in 1980, the population of California is expected to fall between 21919997 and 22084019. This range amounts to only a three-quarters of one percent variation from the expected level.

It should be noted that this model provides population projections which fall between State Department of Finance population forecasts in their series D-100 and E-0.

Given the estimated ratios in Table 1 and the population estimates in Table 2, forecasts of manpower requirements can be made for each of our allied health manpower categories. As Table 3 indicates, three projections are given for each skill in each year.

TABLE 3

Basic Model Projections of California
Allied Health Manpower: 1976 - 1980

CATEGORY	1976	1977	1978	1979	1980
Medical Technology					
Expected	9832	9947	10061	10176	10290
Below	9794	9909	10023	10137	10252
Above	9871	9985	10100	10214	10329
Occupational Therapy					
Expected	2170	2195	2220	2245	2271
Below	2161	2186	2212	2237	2262
Above	2178	2203	2229	2254	2279
Dietetic and Nutritional Services					
Expected	3120	3156	3192	3229	3265
Below	3108	3144	3180	3217	3252
Above	3132	3168	3205	3241	3277
Physical Therapy					
Expected	1771	1791	1812	1832	1853
Below	1764	1784	1805	1825	1846
Above	1777	1798	1819	1839	1860
Health Administration					
Expected	14317	14484	14650	14817	14984
Below	14261	14428	14595	14761	14928
Above	14373	14539	14706	14873	15040
Environmental Health					
Expected	1363	1379	1394	1410	1426
Below	1357	1373	1389	1405	1421
Above	1368	1384	1400	1416	1431
Speech Pathology and Audiology					
Expected	1861	1883	1904	1926	1948
Below	1854	1875	1897	1919	1940
Above	1868	1890	1911	1933	1955

The first projection is based on expected population; the second is based on population one standard deviation below the expected level; and the third is based on population one standard deviation above the expected.

As would be expected, the manpower requirements for each category indicate significant increases. In terms of the

basic model projections, allied health manpower requirements show a 5.65% increase between the 1975 and 1980 time period forecasts for these skill categories.

Clearly, some WARNINGS are in order. First, it is unlikely that all allied health manpower categories would increase in the same percentage terms over time--a major difficulty of the simple ratio method. Second, since no account is taken for supply and demand conditions for these occupations, these forecasts may be inaccurate. Third, there is little likelihood that the ratios, i.e., the d_i, will remain constant in the 1976-1980 time period. Hence, these projections serve only as a tentative baseline to which modified forecasts might be compared.

Empirical Results: Modification for Per Capita Usage Trends

TABLE 4

Increased Usage

CATEGORY	% Increase in Per Capita Usage	Time Period
Occupational Therapy	[a]5.03%	1970 - 1975
Physical Therapy	[b]2.61	1950 - 1973
Medical Technology	[b]4.54	1966 - 1973
Dietetic and Nutritional Services	[c]2.81	1970 - 1975
Health Administration	[b]N.C.	1970 - 1973
Environmental Health	[b]2.27	1970 - 1973
Speech Pathology & Audiology	[b]8.82	1970 - 1973

[a]Based on data provided by the American Occupational Therapy Association

[b]Health Resources Statistics, 1974 and 1971, national data.

[c]Based on data from the California Dietetic Association.

NC: No significant change

The first modification to our basic results is per capita usage of the specified allied health manpower categories. In general, the data indicate that these skill categories are

being used more over time on a per capita basis. Table 4 summarizes the average percentage increases in the ratio of allied health manpower to civilian population over the noted time periods. As table 4 indicates, the ratio of occupational therapy manpower to the population of California has increased 5.03% per year on the average for the 1970-1975 time period. Similar interpretation may be given to the percentages reported in regard to the increases.

In order to account for greater usage of the various health manpower categories, the ratios of manpower to population must be adjusted. The percentage increases in Table 4 were applied to the various d_i in Table 1. For example, the d_i for occupational therapy is assumed to increase from .0001032 in 1975 to .0001083 in 1976 as a result of increased per capita usage of this skill. Table 5 reports manpower projections when the ratios are adjusted to account for increased usage. When the projections in Table 5 are compared with those in Table 3 above, some significant modifications of projected manpower needs can be observed. For example, the basic ratio method projects expected occupational therapy manpower needs at 2271 for 1980 while the modified method projects a figure of 2898. (This represents a 27.6% increase during the 1976-1980 time period.) Table 6 compares the results of the basic with the usage-modified projections. In all categories except health administration, usage adjustments yield significant increases in the projections.

TABLE 5

Projection of California Health Manpower: 1976 - 1980 Usage Modifications

CATEGORY	1976	1977	1978	1979	1980
Occupational Therapy					
Adjusted ratio	0.0001083	0.0001137	0.0001194	0.0001254	0.0001317
Expected	2277	2418	2569	2728	2898
Below	2268	2409	2559	2718	2887
Above	2286	2427	2578	2739	2908
Physical Therapy					
Adjusted ratio	0.00008639	0.0008864	0.00009095	0.00009332	0.00009575
Expected	1815	1885	2008	2030	2106
Below	1808	1877	1948	2023	2098
Above	1822	1892	1963	2038	2114
Meidcal Technology					
Adjusted ratio	0.00459	0.000479	0.000500	0.000522	0.000545
Expected	9650	10188	10757	11358	11991
Below	9612	10148	10716	11315	11947
Above	9688	10227	10798	11400	12036
Dietetic and Nutritional Services					
Adjusted ratio	0.0001525	0.0001567	0.0001611	0.0001656	0.0001702
Expected	3206	3333	3466	3603	3745
Below	3193	3320	3452	3589	3731
Above	3218	3345	3479	3617	3759
Environmental Health					
Adjusted ratio	0.0000662	0.0000677	0.0000692	0.0000707	0.0000723
Expected	1392	1440	1489	1538	1591
Below	1386	1434	1483	1532	1585
Above	1397	1445	1494	1544	1597
Speech Pathology and Audiology					
Adjusted ratio	0.0000963	0.0001047	0.0001139	0.0001239	0.0001348
Expected	2024	2227	2450	2696	2966
Below	2017	2218	2441	2686	2955
Above	2032	2235	2460	2706	2977

TABLE 6

Comparison of Manpower Projections: 1980 Expectations

CATEGORY	Basic Projections	Usage Modified Projections
Medical Technology	10290	11991
Occupational Therapy	2271	2898
Dietetic & Nutritional Svs.	3265	3745
Physical Therapy	1853	2106
Health Administration	14984	14984
Environmental Health	1426	1591
Speech Pathology & Audiology	1948	2966

Empirical Results: Projections Employing California State Department of Finance Estimates

The basic ratios given in Table 1 were used to project manpower requirements employing population projections based on estimates made by the California State Department of Finance. These projections employ an interactive program written especially for forecasting manpower requirements. The program itself is given in Appendix A. Sample output of this software is given in Appendix B. The population series employed are labelled series D-100, Series E-0, Series D-150, and Series C-150. Each of these series is based on alternative assumptions regarding the future population growth in California.

The results of these projections are given in Table 7. All four projections are reported for each allied health manpower category. In general, Series C-150 yields the largest estimates of allied health manpower needs while Series E-0 yields the smallest. The variance between the high and low estimates is approximately 4.4% for 1980.

In addition, since the programming is fully interactive, the user has the option to vary the basic ratios employed as well as to specify the population series to be used in making estimates. This facility lends the ability to quickly and efficiently alter projections as new information becomes available.

Table 8 compares the results of all ratio methods employed in making manpower projections for 1980. In general, the basic projections fall between the E-0 and D-100 population-based estimates. The D-150 and C-150 series produce larger estimates of needs than do the basic series. However, the usage-modified series produces the largest projected needs, again with the exception of health administrators.

TABLE 7

BASIC PROJECTIONS WITH CALIFORNIA DEPARTMENT OF FINANCE POPULATION SERIES

CATEGORY	1976	1977	1978	1979	1980
Medical Technology					
D-100	10054	10190	10326	10462	10598
E-0	9937	10017	10098	10178	10258
D-150	10063	10209	10354	10499	10645
C-150	10095	10255	10416	10576	10736
Occupational Therapy					
D-100	2218	2248	2278	2308	2338
E-0	2193	2210	2228	2246	2263
D-150	2221	2253	2285	2317	2349
C-150	2228	2263	2298	2334	2369
Dietetic and Nutritional Services					
D-100	3190	3233	3276	3319	3363
E-0	3153	3178	3204	3229	3255
D-150	3193	3239	3285	3331	3378
C-150	3203	3254	3305	3356	3407
Physical Therapy					
D-100	1810	1834	1859	1883	1908
E-0	1789	1803	1818	1832	1847
D-150	1812	1838	1864	1890	1916
C-150	1817	1846	1875	1904	1933
Health Administration					
D-100	14639	14837	15035	15233	15431
E-0	14469	14586	14703	14820	14936
D-150	14653	14865	15076	15288	15500
C-150	14699	14932	15166	15399	15632
Environmental Health					
D-100	1471	1490	1510	1530	1550
E-0	1453	1465	1477	1489	1500
D-150	1472	1493	1514	1536	1557
C-150	1477	1500	1523	1547	1570
Speech Pathology & Audiology					
D-100	1902	1928	1954	1980	2805
E-0	1880	1896	1911	1926	1941
D-150	1904	1932	1959	1987	2014
C-150	1910	1941	1971	2001	2032

TABLE 8

FINAL COMPARISON OF RATIO RESULTS: 1980

Category	Basic Pro-jections	Modified Pro-jections	D-100	E-0	D-150	C-150
Medical Technology	10290	11991	10598	10258	10645	10736
Occupational Therapy	2271	2898	2338	2263	2349	2369
Dietetic and Nutritional Services	3265	3745	3363	3255	3378	3407
Physical Therapy	1853	2106	1908	1847	1916	1933
Health Adminis-tration	14984	14984	15431	14936	15500	15632
Environmental Health	1426	1591	1550	1500	1557	1570
Speech Pathology & Audiology	1948	2966	2005	1941	2014	2032

ECONOMETRIC APPROACH

As the review of the literature indicates, attempts have been made to use econometric techniques in the prediction of manpower requirements.[1] While there has been a fair amount of empirical work done in terms of markets for physicians and nurses,[2] the level of effort in the allied health manpower markets has been fairly limited in terms of specific econometric studies.[3] The purpose of this section of the study is to develop and estimate econometric market structures for seven allied health manpower categories. With these econometric structures estimated, the ultimate objective is to employ econometric techniques for forecasting future manpower requirements for the specified allied health fields.

In general, there are three major ways of viewing the allied health manpower market structure.[4] First, there are

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[1]See Bibliography and Abstracts.

[2]For an illustration in each market, see M.S. Feldstein, "An Econometric Model of the Medicare System," QUARTERLY JOURNAL OF ECONOMICS, Vol. 85, No. 1 (February, 1971), pp. 1-20 and Lee Benham, "The Labor Market for Registered Nurses: A Three-Equation Model," REVIEW OF ECONOMICS AND STATISTICS, Vol. 53 (August, 1971), pp. 246-52.

[3]One of the few econometric studies in allied health is found in Paul J. Feldstein and Sander Kelman, "A Framework for an Econometric Model of the Medical Care Sector," in Herbert E. Klarman (ed.), EMPIRICAL STUDIES IN HEALTH ECONOMICS (Baltimore, Johns Hopkins Press, 1970), pp. 171-190.

[4]For a review of treatments, see Jeffrey H. Weiss, THE CHANGING JOB STRUCTURE OF HEALTH MANPOWER (unpublished Ph.D. dissertation, Harvard University, 1966), pp. 1-37.

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some studies that treat the sectors of the allied health field as if the market is always in equilibrium.[5] Second, there are a number of studies that make a monopsony argument for medical and health care services.[6] Third, there are various studies that consider the shortage of medical personnel.[7] In all three conceptual methodologies, there is a tendency to treat the supply and the demand for health care manpower separately. Such treatment may be, in part, due to the implicit departures from economic theory which are necessary in considering the supply relationships. As an alternative, the present study employs simultaneous treatment of supply and demand. In addition, an effort is made to deal with the possibilities of disequilibrium in the allied health manpower markets.[8]

PRODUCTION OF HEALTH SERVICES

In general, the increase in the price of medical services over the past few decades has led researchers to consider the production of these services. There is an underlying implication

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[5]Feldstein and Kelman, op. cit., p. 182 and p. 186.

[6]These studies take the lead of Kenneth J. Arrow, "The Welfare Economics of Medical Care," in H. Cooper and Anthony J. Culyer (eds.), HEALTH ECONOMICS (Baltimore: Penguin Books, Inc.,) p. 25.

[7]Eugene J. Devine, ANALYSIS OF MANPOWER SHORTAGES IN LOCAL GOVERNMENT (New York: Praeger Publishers, 1970), pp. 59-62.

[8]For a recent attempt to handle labor market disequilibrium, see Kenneth J. Kopecky, "A Disequilibrium Model of a Hiring-Hall Labor Market," ECONOMIC INQUIRY, Vol. 14, No. 2 (June, 1976), pp. 201-220.

that the medical services industry is providing smaller gains to productivity than the rest of the economy. Thus, the bulk of the production function of health services literature isolates its attention on productivity. These efforts can be categorized as: (1) time-motion studies[9]; (2) substitutability of physician's with other skills research[10]; (3) optimization studies[11]; and (4) institutional restructuring studies[12]. All these studies make reference to production functions or cost functions and require some sort of information about them.

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[9]See A.B. Bergman, W. Passel and R.J. Wedgwood, "Time and Motion Study of Practicing Pediatricians," PEDIATRICS, Vol. 38, No. 254 (August, 1966).

[10]R. Zeckhauser and M. Eliastam, "Productivity Potential of the Physician Assistant," JOURNAL OF HUMAN RESOURCES, Vol. 9, No. 1 (Winter, 1974), pp. 95-116.

[11]H.E. Frech and P.B. Ginsburg, "Optimum Scale and Medical Practice: A Survivor Analysis," JOURNAL OF BUSINESS, Vol. 47, No. 1 (January, 1974), pp. 23-36; F.L. Gollady, M.E. Manser and K.R. Smith, "Scale Economies in the Delivery of Medical Care: A Mixed Integer Programming Analysis of Efficient Manpower Utilization," JOURNAL OF HUMAN RESOURCES, Vol. 9, No. 1 (Winter, 1974), pp. 50-62; K.R. Smith, M. Miller and F.L. Gollady, "An Analysis of the Optimum Use of Inputs in the Production of Medical Services," JOURNAL OF HUMAN RESOURCES, Vol. 7, No. 2 (Spring, 1972), pp. 208-25; J.J. Wiorkowski and W.R. McLeod, "Prediction and Control of the Size of an Input-Output System," JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION, Vol. 66, No. 336 (December, 1971), pp. 712-19.

[12]H.A. Cohen, "Cost Functions of Hospital Diagnostic Procedures: A Possible Argument for Diagnostic Centers," JOURNAL OF ECONOMICS AND BUSINESS, Vol. 25, No. 2 (Winter, 1973), pp. 83-88; J.P. Newhouse, "The Economics of Group Practices," JOURNAL OF HUMAN RESOURCES, Vol. 8, No. 1 (Winter, 1973) pp. 37-56.

Explicit use of a production function is made in numerous empirical studies dealing with health services. In general, these studies amount to single equation models and estimation takes place employing single equation techniques.[13] Since none of these studies has much to say about the market structures of the inputs, little information is gained for the purposes of the present effort.

In order to develop sufficient generality, it seems imperative that one should distinguish between the production of medical services (i.e., produced by doctors in an outpatient setting) and the more general production of health services. The production of health services is not singularly dependent on the skills of a physician. Since our concern is with the production of health services, the theoretical underpinnings of what follows treats the physician as another input in the production process.

The health services industry is highly complex in nature. The theoretical element which adds to this complexity is the multiple output of the industry. In general, most empirical

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[13]See J.W. Kovner, A PRODUCTION FUNCTION FOR OUTPATIENT MEDICAL FACILITIES, unpublished doctoral dissertation, University of California, Los Angeles, 1968; U. Reinhardt, "A Production Function of Physicians Services," REVIEW OF ECONOMICS AND STATISTICS, Vol. 54, No. 1 (February, 1972), pp. 55-66; M.S. Feldstein, "Rising Price of Physician's Services," REVIEW OF ECONOMICS AND STATISTICS, Vol. 6 (May, 1970), pp. 121-133; Zechauser and Eliastam, loc. cit.; R. Auster, I. Leveson, and D. Saracheck, "The Production of Health: An Explanatory Study," JOURNAL OF HUMAN RESOURCES, Vol. 4, No. 4 (Fall, 1969), pp. 411-436.

studies consider only a single output.[14] Although the multiple output nature of the production process of health services is recognized, the outputs of the process are viewed separately.[15] Such separate treatment of the production process allows theoretically implausible interpretation.

To account for the simultaneous and interdependent production of medical services, an implicit production function is proposed. Let

(1) $$G(X_1,\ldots,X_n,Z_1,\ldots,Z_m) = 0$$

represent the implicit production for health services where there are n outputs, $X_1,\ldots,X_n$, and m inputs, $Z_1,\ldots,Z_m$. For example, the outputs could consider physician's examinations, X-ray services, laboratory tests, surgery, home nursing, and birth control clinics. The m inputs could be disaggregated to consider laboratory equipment, bed, etc., while the labor input could consider physician's time, health administrator's time, etc. The implicit production function in equation (1) could be disaggregated as far as the existing data permit.

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[14]See L.J. Kimbell and R.T. Deane, "Analysis of the Utilization of Ancillary Personnel Using Production Functions," and B.H. Kehrer and M.D. Intriligator, "Malpractice and the Employment of Allied Health Personnel," University of Southern California, op. cit.

[15]Richard M. Bailey, "Philosophy, Faith, Fact and Fiction in the Production of Medical Services," INQUIRY, Vol. VII, No. 1 (March, 1970), p. 48.

When explicit treatment of a particular output, say X_3, is made, the resulting model is somewhat different than the basic textbook illustration of a single output production function. Let

$$X_3 = f^3(X_1, X_2, X_4, \ldots X_n, Z_1, \ldots, Z_m) \quad (2)$$

represent the explicit production X_3, say home nursing services. Note that X_3 is a function of the n-1 other outputs as well as the m inputs. As an illustration, assume that equation (2) takes on a Cobb-Douglas form[16]:

$$X_3 = AX_1^{\alpha_1} X_2^{\alpha_2} Z_1^{\beta_1} Z_2^{\beta_2} Z_3^{\beta_3} Z_4^{\beta_4} Z_5^{\beta_5} \quad (3)$$

where X_1 = physician's examination

X_2 = laboratory tests

X^3 = home nursing services

Z_1 = physician's hours

Z_2 = nurse's hours

Z_3 = health administrator's hours

Z_4 = medical technician's hours

Z^5 = capital

and $\alpha_1, \alpha_2, \beta_1, \ldots, \beta_5$, and A are parameters. For the sake of analysis, only three outputs and five inputs are considered.[17]

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[16]For the uses of the Cobb-Douglas form in health studies, see Kimbell and Deane, op. cit., Deane and McFarland, op. cit., and Kehrer and Intriligator, op. cit. The present discussion using the Cobb-Douglas production function is only to illustrate and clarify the subject matter.

[17]For an illustration of a multiple output-multiple input production function, see L.R. Klein, A TEXTBOOK OF ECONOMETRICS (Englewood Cliffs: Prentice-Hall, Inc., 1974), pp. 363-373.

By estimating a production surface like equation (3) some interesting and useful theoretical insights might be derived. For example, the degree of complementarity (or substitution) between inputs could be determined; that is, how well do health administrators and nurses substitute in the production of home nursing services. As well, output complimentarities could be estimated. Some indication of the trade-offs between physicians' examinations and laboratory tests could be determined. Finally, the substitution between inputs, for example, physician's time and medical technician's time could be estimated. Such a production function could lead to important insights in the health production process.

The estimation of a production function itself is beyond the scope of the present effort. However, it does provide a set of plausible, theoretical insights when integrated with economic optimization techniques discussed below.

ECONOMIC OPTIMIZATION

While many studies consider the production of health services, few explicitly treat the underlying economic optimization process. If the main economic problem is to meet the existing or given level of health services at minimum cost, the optimization process reduces to minimizing:

(4) $$C \min = b_1Z_1 + b_2Z_2 + b_3Z_3 + b_4Z_4 + b_5Z_5$$

subject to equation (3) where $b_1,\ldots,b_5$ represents the respective input prices. By forming the Lagrangian function and partially

differentiating with respect to $Z_1,\ldots,Z_5$ and λ, the first order conditions become:

$$
\begin{aligned}
&b_1 - \lambda \frac{\partial X_3}{\partial Z_1} = 0 \\
&b_2 - \lambda \frac{\partial X_3}{\partial Z_2} = 0 \\
&b_3 - \lambda \frac{\partial X_3}{\partial Z_3} = 0 \\
&b_4 - \lambda \frac{\partial X_3}{\partial Z_4} = 0 \\
&b_5 - \lambda \frac{\partial X_3}{\partial Z_5} = 0 \\
&X_3 - A X_1^{\alpha_1} X_2^{\alpha_2} Z_1^{\beta_1} \ldots Z_5^{\beta_2} = 0
\end{aligned}
\tag{5}
$$

Note that λ, the Lagrangian multiplier, is normally interpreted as:

$$\lambda = \frac{\Delta C}{\Delta X_1} \tag{6}$$

or the marginal cost of producing home nursing services.

Under competition, the marginal cost of an output is equated to the selling price. However, since most health services are the outputs of non-profit organizations, it may be that the services are provided as long as the price meets the marginal cost of the output, e.g., $P_3 \lambda$ in this case. By taking the third equation of equation set (5) and upon substitution and manipulation, the following is derived:

$$\frac{b_3}{P_3} = \frac{\partial X_3}{\partial Z_3} \tag{7}$$

Equation (7) argues that the ratio of the input price and the selling price reflects the marginal product of the input, e.g. health administrator's hours in the production of home nursing services.

DERIVED DEMAND

The optimization conditions specified above allow for the derivation of input demand. Assuming that optimization has occurred, equation (7) can be manipulated into a form:

$$(8) \qquad \frac{b_3 Z_3}{p_3 X_3} = \beta_3$$

For the illustrative production function in equation (3), there are four other derived demand functions (i.e., for Z_1, Z_2, Z_4, and Z_5). The derived demand indicates that the demand for an input is a function of own-price, the selling price of the output, and the parameters and levels of the production process. Thus, the specified model is capable of providing theoretically viable results.

ALLIED HEALTH MANPOWER MARKET STRUCTURES: EQUILIBRIUM CASE

When the derived demands considered above are integrated with supply conditions, the variables in a plausible market structure may be determined. It is important to note that the structure of a market requires the simultaneous interaction of supply and demand considerations. On the demand side, consideration is given to the composition of population, relative prices, and income. On the supply side, an attempt is made to capture the influence of migration, skill substitu-

tion, and productivity.[18] Table 1 summarizes the independent variables included in each of the seven allied health manpower markets under consideration. The dependent variables for each

TABLE 1

Exogenous Variables Included in Allied Health Manpower Market Structures

CATEGORY	DEMAND	SUPPLY
OCCUPATIONAL THERAPY	DIFFERNC, POPLTION, INCOME, RL PRICE, TIME, DUMMY 1, DUMMY 2	DIFFERNC, RL WAGE, DEGREE, UNEMPLMT, MIGRTN, TIME
PHYSICAL THERAPY	DIFFERNC, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME	DIFFERNC, DEGREE, UNEMPLMT, MIGRTN, RL WAGE, TIME
MEDICAL TECHNOLOGY	DIFFERNC, BED, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME	DIFFERNC, RL WAGE, DEGREE, UNEMPLMT MIGRTN, TIME
DIETETIC AND NUTRITIONAL SERVICES	DIFFERNC, BED, ENROLL, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME	DIFFERNC, DEGREE, UNEMPLMT, MIGRTN, RL WAGE, TIME
HEALTH ADMINISTRATION	DIFFERNC, INCOME, RL PRICE, BED, POPLTION, TIME, DUMMY 1, DUMMY 2	DIFFERNC, DEGREE, UNEMPLMT, MIGRTN, BED/CAP, TIME
ENVIRONMENTAL HEALTH	DIFFERNC, POPLTION, INCOME, RL PRICE, TIME, DUMMY 1, DUMMY 2	DIFFERNC, RL WAGE, UNEMPLMT, MIGRTN, TIME, DEGREE
SPEECH PATHOLOGY & AUDIOLOGY	DIFFERNC, ENROLL, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME	DIFFERNC, DEGREE, MIGRTN, UNEMPLMT, TIME

[18]For a general discussion of the reasoning underlying the inclusion of these variables, see the section on the "Modified Ratio Approach," pp. 1-3, above.

market are quantity and wage rate. In each of the seven markets there are variables which are specific to only that market as well as variables which may be found in alternative allied health manpower market structures.

The variables which are used in common are defined as:

POPLTION = California civilian population

INCOME = California personal income

RL PRICE = Relative prices measured as California's medical services price index/consumer price index.

DUMMY 1 = Rank of California population under 5 years of age and over 65 years of age to total resident population.

DUMMY 2 = Rank of the male/female population ratio in California

UNEMPLMT = California unemployment rate (old series)

MIGRTN = California net migration

TIME = Time in years

A discussion of particular market structures follows with specification of variables applicable exclusively to each category.

OCCUPATIONAL THERAPY MODEL

The supply and demand for occupational therapists are given as:

(9) $Q^d = f(\text{WAGE, DIFFERNC, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME})$

and

(10) $Q^s = g(\text{WAGE, DIFFERNC, RL WAGE, DEGREE, UNEMPLMT, MIGRTN, TIME})$

Where: Q = Index of filled positions for occupational therapists in California hospitals

WAGE = Real wage of California occupational therapists in hospitals

DIFFERNC = Authorized minus filled positions for occupational therapists in California hospitals

RL WAGE = Lowest occupational therapist's wage divided by lowest physical therapist's wage

DEGREE = Total number of baccalaureate degrees in California

and where all other variables have been defined previously.

From equation (9), the demand for occupational therapists is assumed to be a function of seven exogenous variables as well as an endogenous real wage. The INCOME variable is included in order to measure the influence of income levels on the demand for occupational therapists. The RL PRICE variable attempts to account for relative prices. DUMMY 1 and DUMMY 2 are included in order to account for the influence of the age and sex distribution of the population. POPLTION accounts for general population influences on the demand for occupational therapists while TIME is employed to capture possible trends. The DIFFERNC variable is employed in order to account for the possibility of disequilibrium.

On the supply side, the RL WAGE variable attempts to account for relative wages. From information gathered by surveying experts, it was found that the closest substitutable

skills seem to be between occupational and physical therapists. Thus, RL WAGE serves the dual purpose of accounting for ease in skill substitutability and for isolating the influence of relative wages on the supply of effort. Since a consistent series on occupational therapy graduates was not available, the DEGREE variable was employed as a proxy. Since a greater percentage of California baccalaureate degree holders have graduated in occupational therapy in recent years, this series admittedly will tend to understate the influence of these individuals on the supply conditions. The UNEMPLMT variable is included to account for major changes in California employment conditions. Again DIFFERNC is included to derive the possible influence of disequilibrium while TIME is used to capture possible trends. The MIGRTN variable is meant to capture the influence of individuals moving into and out of the state.

PHYSICAL THERAPY MODEL

The supply and demand for physical therapists are given as:

(11) $Q^d = f(\text{WAGE, DIFFERNC, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME})$

and

(12) $Q^s = g(\text{WAGE, DIFFERNC, DEGREE, UNEMPLMT, MIGRTN, RL WAGE, TIME})$

where: Q = Index of filled positions for physical therapist I in California hospitals

WAGE = Real wage of California physical therapist I in hospitals

DIFFERNC = Authorized minus filled positions for physical therapist I in California hospitals

RL WAGE = Wage of a physical therapist I divided by the wage of a physical therapist II.

DEGREE = Ratio of 1972 physical therapy graduates/ total graduates times total baccalaureate degrees conferred in California

and where all other variables have been defined previously.

In general, the rationale behind the inclusion of these variables is similar to that which was discussed above. However, two exceptions should be noted. Since a wage series for a close substitute, i.e. physical therapist II, was available, the RL WAGE variable is somewhat different than the one used in the previous case. Rather than measuring ease of skill substitutability between professions, RL WAGE measures substitutability within the profession. Second, the series for baccalaureate degrees in California is adjusted to account for the known percentage of California physical therapy graduates for 1972.

MEDICAL TECHNOLOGY MODEL

The supply and demand for medical technologists are given as:

(13) Q^d = f(WAGE, DIFFERNC, BED, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME)

and

(14) $Q^S = g(WAGE, DIFFERNC, RL\ WAGE, DEGREE, UNEMPLMT, MIGRTN, TIME)$

where Q = Index of filled positions for laboratory technologists in California hospitals

WAGE = Real wage of California laboratory technologists

DIFFERNC = Authorized minus filled positions for laboratory technologists in California

BED = Total number of licensed beds in California

RL WAGE = Wage of laboratory assistant I divided by the wage of a laboratory technologist

DEGREE = Ratio of 1973 medical technology degree to total graduates times total baccalaureate degrees in California

and where all other variables have been defined previously.

While the model is quite similar to others discussed above, a major addition to the demand function is evident in equation (13). From a recent American Medical Technologists Survey[19], 50% of the membership were employed in hospitals. In order to account for this situation, the total number of licensed beds in California was included in the demand relationship. In addition, the RL WAGE variable is measured as the ratio of the wage of a California laboratory assistant I to the wage of a laboratory technologist. Again the DEGREE variable adjusts total baccalaureate degrees awarded in California with 1973 figures.

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[19]American Medical Technologists, REPORT ON MEMBERSHIP-EDUCATION-EMPLOYMENT SURVEY, April 1, 1976.

DIETETIC AND NUTRITIONAL SERVICES MODEL

The supply and demand for dietetic and nutritional services are given as:

(15) $Q^d = f(WAGE, DIFFERNC, BED, ENROLL, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME)$

and

(16) $Q^s = g(WAGE, DIFFERNC, DEGREE, UNEMPLMT, MIGRTN, RL WAGE, TIME)$

where: Q = Index of filled positions for a Food Administrator I in California

WAGE = Real wage for a California Food Administrator I

DIFFERNC = Authorized minus filled positions for Food Administrator I's in California

RL WAGE = Wage of a Food Administrator I divided by the wage of a nutritional consultant II

DEGREE = Ratio of 1971 Dietetic and Nutritional Services graduates to total California graduates times total California baccalaureate degrees.

BED = Total number of licensed beds in California

ENROLL = Total enrollment in California public schools

and where all other variables have been defined previously.

The major addition to this particular market is the inclusion of both the BED variable and the ENROLL variable. The inclusion of these variables is in response to expert opinions.[20] In the survey effort, most experts agreed that

[20] See Summary of Findings of the questionnaire administered at the CSUC Health Manpower Conference, March 12, 1976.

the representative graduate in this allied health field was employed in either a hospital or a school. Thus, these two variables were included in the demand relationship.

HEALTH ADMINISTRATION MODEL

The supply and demand for health administrators are specified as:

(17) $Q^d = f(WAGE, DIFFERNC, INCOME, RL\ PRICE, BED, POPLTION, DUMMY\ 1, DUMMY\ 2, TIME)$

and

(18) $Q^s = g(WAGE, DIFFERNC, DEGREE, UNEMPLMT, MIGRTN, BED/CAP, TIME)$

where Q = Index of filled positions for California hospital (business) administrators

WAGE = Real wage for California hospital administrators

DIFFERNC = Authorized minus filled positions for California hospital administrators

BED = Total number of licensed beds in California

DEGREE = Total number of University of California master's degrees conferred

BED/CAP = Total number of licensed beds in California divided by California civilian population

and where all other variables have been defined previously.

The major modifications in the Health Administrator Model are the change in the measurement of the DEGREE variable and the inclusion of a beds per capita variable. The general indication seems to be that individuals holding hospital

administrator jobs tend to have graduate degrees. Since the University of California system has been conferring such degrees,[21] the number of masters degrees conferred was employed in the supply relationship.

ENVIRONMENTAL HEALTH MODEL

The supply and demand for environmentalists are given as:

(19) $Q^d = f(\text{WAGE, DIFFERNC, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME})$

and

(20) $Q^s = g(\text{WAGE, DIFFERNC, RL WAGE, UNEMPLMT, MIGRTN, DEGREE, TIME})$

where Q = Index of filled positions for a California sanitarian II

WAGE = Real wage of a sanitarian II

DIFFERNC = Authorized minus filled positions for California sanitarian II's

RL WAGE = Wage of sanitarian II divided by wage of a consulting sanitarian in California

DEGREE = Total number of California undergraduate degrees conferred

and where all other variables have been defined previously.

In general, there is little modification in the environmental health model. The degree problem is somewhat troublesome. In the State of California registration is required.

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[21]HEALTH RESOURCES STATISTICS, 1974, U.S. Department of Health, Education, and Welfare, p. 33.

State registration is obtained by passing an examination. In addition, the applicant must submit evidence of a bachelor's degree and either one year of experience in sanitation or 16 additional semester hours in public health. Since 14 institutions in California are known to have undergraduate programs in environmental health,[22] the DEGREE variable simply reflects the general level to total undergraduate degrees conferred.

SPEECH PATHOLOGY AND AUDIOLOGY MODEL

The supply and demand for speech pathologists and audiologists are given as:

(21) $Q^d = f(\text{WAGE, DIFFERNC, ENROLL, POPLTION, INCOME, RL PRICE, DUMMY 1, DUMMY 2, TIME})$

and

(22) $Q^s = g(\text{WAGE, DIFFERNC, DEGREE, MIGRTN, UNEMPLMT, TIME})$

where Q = Index of speech development and corrections positions filled in California

WAGE = Real wage of a hearing conservation specialist in California

DIFFERNC = Authorized minus filled positions for a speech development and corrections specialist

ENROLL = Total enrollment in California public schools

DEGREE = Total number of graduates estimated by the American Speech and Hearing Association for the United States

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[22] Ibid., p. 121

and where all other variables have been previously defined.

The model specified in equations (21) and (22) is clearly the most troublesome. First, since an adequate time series for a particular skill category employment level and wage was not available, two separate wage and quantity series were, of necessity, employed. While such methodology cannot be theoretically defended, it must be noted that, where the time series for Speech Development and Correction data and Hearing Conservation specialists data overlapped, the behavior of the series was quite similar. Second, the American Speech and Hearing Association produces estimates of the total number of graduates for the United States.[23] Thus, the DEGREE variable employed assumes that the California series varies in a similar fashion. In addition, the data for 1956-1959 were approximated.

ALLIED HEALTH MANPOWER MARKET STRUCTURES: EMPIRICAL RESULTS FOR THE EQUILIBRIUM CASE

The market structures specified in equations (9) through (22) were estimated using two-stage least squares (TSLS). Each model is overidentified.[24] Since a market equilibrium is presumed, each set of supply and demand equations implicitly assumes a market clearing identity, i.e., supply equals demand. Table 2 summarizes the two-stage least squares

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[23] Ibid., p. 305.

[24] See Carl Christ, ECONOMETRIC MODELS AND METHODS (New York: John Wiley, 1966), pp. 408-409.

estimates for each model. The first line gives the TSLS parameter estimates. The second line gives the computed Student's t statistic. In addition, adjusted R^2s, Durbin-Watson statistics, F statistics, and squared errors are reported. The first equation in each category represents the estimated demand function while the second equation represents the estimated supply function. The time period over which the sets of equations were estimated is also noted.

TABLE 2

Summary of TSLS Estimates

For Allied Health Manpower

Markets in Equilibrium

OCCUPATIONAL THERAPY 1956-1973		PHYSICAL THERAPY 1956-1975	
1 Quantity TSLS	2 Wage TSLS	1 Quantity TSLS	2 Wage TSLS
WAGE	QUANTITY	WAGE	QUANTITY
-0.001324	-214.619229	-0.001435	149.741119
-0.752833	-0.645942	-0.972666	1.632717
DIFFERNC	DIFFERNC	DIFFERNC	DIFFERNC
-0.015033	-3.728678	-0.013212	2.051909
-4.666762	-0.678187	-2.617064	1.584208
POPLTION	RL WAGE	POPLTION	DEGREE
0.138685	389.749590	0.526347	1.396515
0.321919	1.073780	1.528533	1.061092
INCOME	DEGREE	INCOME	UNEMPLMT
-0.008884	-5.832664	0.017642	-17.808945
-0.259238	-0.740260	0.873410	-3.232114
RL PRICE	UNEMPLMT	RL PRICE	MIGRTN
1.755291	0.686796	3.799805	0.029688
0.673892	0.049607	1.189220	0.280263
TIME	MIGRTN	DUMMY 1	RL WAGE
-0.019683	-0.073537	-0.005790	1469.072500
-0.053177	-0.377100	-0.073491	4.015457
DUMMY 1	TIME	DUMMY 2	TIME
-0.010720	33.955172	-0.043225	-4.226392
-0.175762	1.162277	-0.426859	-0.291820
DUMMY 2	CONSTANT	TIME	CONSTANT
0.023378	297.503515	-0.324341	-816.686270
0.290737	1.480778	-1.222665	-2.401977
CONSTANT	R-SQ./SE	CONSTANT	R-SQ./SE
-1.694826	0.908669	-8.885040	0.952493
-0.215100	19.206134	-1.456001	16.844522
R-SQ./SE	DW(D)/F	R-SW./SE	DW(D)/F
0.789439	2.571000	0.748589	1.564867
0.070776	25.160246	0.102027	55.420058
DW(D)/F		DW(D)/F	
2.571406		1.933013	
8.967083		8.071667	

TABLE 2

(continued)

MEDICAL TECHNOLOGY 1956-1975		DIETETIC AND NUTRITIONAL SERVICES 1958-1975	
1 Quantity TSLS	2 Wage TSLS	1 Quantity TSLS	2 Wage TSLS
WAGE	QUANTITY	WAGE	QUANTITY
0.000154	136.116151	-0.001372	103.636373
0.139903	2.648987	-1.056809	1.639007
DIFFERNC	DIFFERNC	DIFFERNC	DIFFERNC
-0.007383	3.047215	-0.009100	3.247301
-1.424876	3.016700	-0.404580	0.866298
BED	RL WAGE	BED	DEGREE
0.000291	-9.801659	-0.001684	-0.880033
0.476401	-0.041637	-2.299102	-0.266664
POPLTION	DEGREE	ENROLL	UNEMPLMT
0.378351	-0.275472	-0.057804	-13.375859
2.389135	-0.864125	-0.113412	-1.794793
INCOME	UNEMPLMT	POPLTION	MIGRTN
-0.001220	-15.992386	0.334251	0.051508
-0.128769	- 4.181801	0.905753	0.418245
RL PRICE	MIGRTN	INCOME	RL WAGE
-0.054728	0.042293	0.008184	785.132095
-0.027973	0.377470	0.505373	1.948901
DUMMY 1	TIME	RL PRICE	TIME
-0.079754	23.308689	-0.975278	17.036731
-1.851865	4.061747	-0.337952	1.521790
DUMMY 2	CONSTANT	DUMMY 1	CONSTANT
-0.015226	409.576069	0.094349	-128.647756
-0.228705	1.880233	0.744932	-0.345663
TIME	R-SW./SE	DUMMY 2	R-SQ./SE
-0.151767	0.976966	-0.076628	0.931425
-1.212233	14.910587	-0.483720	17.987892
CONSTANT	DW(D)/F	TIME	DW(D)/F
-4.004446	2.44118	-0.116587	2.859942
-1.247366	116.121939	-0.549405	33.986474
R-SQ./SE		CONSTANT	
0.876798		-2.247006	
0.053303		-0.334028	
DW(D)/F		R-SQ./SE	
2.038065		0.823321	
16.024282		0.065166	
		DW(D)/F	
		2.624648	
		8.921991	

TABLE 2

(continued)

HEALTH ADMINISTRATION 1956-1975		ENVIRONMENTAL HEALTH 1957-1975	
1 Wage TSLS	2 Quantity TSLS	1 Quantity TSLS	2 Wage TSLS
QUANTITY	WAGE	WAGE	QUANTITY
-626.376588	0.000186	-0.003344	104.359350
-1.829878	0.307547	-1.918604	2.572278
DIFFERNC	DIFFERNC	DIFFERNC	DIFFERNC
-76.631437	-0.019743	-0.022211	-1.105984
-3.695504	-0.720139	-1.286381	-0.328802
INCOME	DEGREE	POPLTION	RL WAGE
-3.519502	0.000018	0.451029	0.253626
-0.728156	0.224241	1.623685	0.871449
RL PRICE	UNEMPLMT	INCOME	UNEMPLMT
266.117669	0.040034	-0.003455	-14.877727
0.197424	1.728686	-0.196432	-1.845757
BED	MIGRTN	RL PRICE	MIGRTN
-0.535381	0.000861	-0.222033	-0.040110
-0.739823	2.230474	-0.071357	-0.271402
POPLTION	BED/CAP	TIME	TIME
109.940254	-59.938132	-0.098421	0.910073
1.616716	-5.756836	-0.442338	0.216006
TIME	TIME	DUMMY 1	DEGREE
-5.468633	0.043689	0.047289	0.040537
-0.147994	1.461696	0.667514	2.146821
DUMMY 1	CONSTANT	DUMMY 2	CONSTANT
-6.346471	0.670999	-0.136663	560.216219
-0.295288	0.981151	-1.387765	6.274328
DUMMY 2	R-SQ./SE	CONSTANT	R-SQ./SE
-105.558658	0.853299	-3.143154	0.953650
-2.329541	0.069318	-0.571451	19.214935
CONSTANT	DW(D)/F	R-SQ./SE	DW(D)/F
484.533343	1.93311	0.753471	2.425076
0.410367	16.787877	0.101161	53.907385
R-SQ./SE		DW(D)/F	
0.958485		2.072249	
35.674489		7.876710	
DW(D)/F			
3.012051			
49.740962			

TABLE 2

(continued)

SPEECH PATHOLOGY AND AUDIOLOGY
1956-1971

1 Quantity TSLS	2 Wage TSLS
WAGE	QUANTITY
0.003695	18.344628
1.837448	0.263113
DIFFERNC	DIFFERNC
0.033981	-6.347150
1.574834	-1.787773
ENROLL	DEGREE
1.826543	5.455202
1.299598	0.430619
POPLTION	MIGRTN
-1.113363	-0.001428
-1.497899	-0.011829
INCOME	UNEMPLMT
-0.060083	-12.208235
-1.205512	-1.439387
RL PRICE	TIME
-5.638890	18.091152
-2.015180	3.056120
DUMMY 1	CONSTANT
-0.499254	746.577357
-1.487200	8.737181
DUMMY 2	R-SQ./SE
-0.214638	0.960658
-0.476055	18.682711
TIME	DW(D)/F
0.491179	2.095384
1.086177	62.045513
CONSTANT	
14.344968	
1.392691	
R-SQ./SE	
0.947393	
0.058072	
DW(D)/F	
2.549588	
31.014857	

Since quantities and wages are endogenous in each market structure, one of them must serve as an explanatory endogenous variable while the other serves as a dependent endogenous variable. Hence, if the right-hand side of the demand equation is quantity, the explanatory endogenous must be wages and vice versa.

Occupational Therapy Model: Empirical Results

The results of the TSLS estimates for the Occupational Therapy Model are somewhat encouraging. On the demand side, 78 percent of the variation in the quantity demanded is explained by the variables in the equation. In terms of the supply equation 90 percent of the variability of wages is explained. Both F statistics are significant at the one percent level. Unfortunately, no clear rejection of the hypothesis that either of the equations exhibits negative first-order autocorrelation could be made.[25] In addition, the interpretations given below must be considered cautiously due to the lack of statistical significance of some of the estimated coefficients.

The relationship between quantity and real wage in the demand is negative as would be expected from economic theory. The positive coefficient on the POPLTION variable indicates that the demand for occupational therapists rises when civilian population increases. The income variable coefficient is negative. In a strict theoretical sense, this sign might support an argument that occupational therapists are inferior

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[25]See J. Johnston, ECONOMETRIC METHODS (New York: McGraw-Hill, 1972), pp. 249-252, for a discussion.

inputs in the production of health services.[26] The relative price variable, i.e., RL PRICE, has a positive sign which implies that occupational therapists are not pricing themselves out of the market. The age and sex dummy variables exhibit opposite signs. As the California population of individuals under 5 years of age and over 65 years of age increases, the historical rank falls. Thus, the demand for occupational therapists rises. As the male/female population ratio decreases, this category is assigned a small rank number. Consequently, the argument is made that the greater the proportion of women in California the less is the demand for occupational therapists. The most statistically significant variable seems to be DIFFERNC. As the disparity between authorized and filled positions becomes smaller, the quantity of occupational therapists demanded increases. Finally, there seems to be some evidence that the demand for occupational therapists may be falling over time.

On the supply side, the relative wage variable, unemployment and time have positive coefficients. As the wage for occupational therapists rises relative to the wage of physical therapists, the supply of occupational therapists tends to increase. In addition, as California unemployment rates rise the supply of occupational therapists rises. However, the most

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[26]See Daniel C. Vandermeulen, LINEAR ECONOMIC THEORY (Englewood Cliffs: Prentice-Hall, 1971), p. 219.

significant variable seems to be the positive trend in the supply of this allied health manpower category. Surprisingly, the migration variable and the degree variable exhibit negative coefficients. The DEGREE variable's insignificance may, in part, be explained by the lack of a consistent time series of occupational therapy graduates for California. The DIFFERNC variable's negative coefficient indicates that as the difference between authorized and filled positions decreases the supply increases. From a purely theoretical point of view, the negative relationship between real wage and the quantity supplied may indicate that the income effect of a wage rate change dominates the substitution effect for occupational therapists.

Physical Therapy Model: Empirical Results

In general the empirical results of the Physical Therapy Models are somewhat better than those for Occupational Therapy. On the demand side, 74 percent of the variation in quantity demanded is explained by the variables in the demand equation. In terms of the supply equation, 95 percent of the variation of wages is explained. Both F statistics are statistically significant at the one percent level. The Durbin-Watson statistics make the test for positive first-order autocorrelation inconclusive. Again, only cautious interpretations are possible because of the lack of statistical significance of some of the estimated coefficients.

On the demand side, the relationship between quantity demanded and wages is negative and significant at the 80 per-

cent level. Thus, as the real wage rises, the quantity demanded tends to fall. The DIFFERNC variable is negative and statistically significant at the one percent level. Population, income and relative prices are positive indicating that as these variables increase so does the demand. These empirical results are quite consistent with what would have been predicted by economic theory. Both dummy variables exhibit negative signs but are not statistically significant. The time variable indicates a tendency for the demand for physical therapists to fall over time.

The supply equation indicates a positive relationship between the quantity supplied and the real wage. This result is consistent with the traditional concept of a competitive labor market. The coefficient for quantity in the supply equation is significant at the 90 percent level. In order to interpret the results in a traditional manner, i.e., with quantity on the left hand side of the equation, a simple algebraic manipulation is necessary. By moving quantity to the left hand side of the equation and the wage variable to the right hand side, a functional form as in equation (12) is derived. This manipulation reverses the sign of the reported coefficients for supply in Table 2.[27] Thus, the quantity of physical therapists supplied decreases when DIFFERNC, DEGREE, MIGRTN, and RL WAGE increase. Alternatively, the supply of effort increases with increases in UNEMPLMT and TIME. UNEMPLMT and RL WAGE are by far statistically the most significant variables in the supply equation. Since the quantity of physical therapists rises with the unemploy-

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[27] Note that the signs in the supply equation for occupational therapists did not reverse due to the negative coefficient on the quantity variable in that equation.

ment rate, there is some evidence that an additional worker phenomenon is prevalent.[28] The RL WAGE variable indicates that as the wage of a physical therapist I rises in relation to a physical therapist II, the supply of effort in the former category falls. This result has intuitive appeal from the standpoint that an employment ratchet effect may be at work. Specifically, as promotions occur, there may be a tendency not to return to the lower skill category, thus diminishing the supply of effort.

Medical Technology Model: Empirical Results

The empirical results of the Medical Technology Model are quite encouraging: 87 percent of the variation in quantity demand is explained by the variables in the demand equation, while on the supply side, 97 percent of the variation in wages is explained. Both F statistics are statistically significant at the one percent level. The Durbin-Watson statistics in both equations indicate that the hypothesis that positive first-order autocorrelation is exhibited is firmly rejected. Since all coefficients are not statistically significant, only cautious interpretations are possible.

On the demand side, the two most statistically significant variables appear to the POPLTION and DUMMY 1. As population rises, a statistically significant increase in the demand for medical technologists would be expected. As the proportion of the California population of young and old increases, the

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[28]This type of interpretation is fairly common in the economics literature. See William G. Bowen and T. A. Finnegan, "Labor Force Participation and Unemployment", in Arthur M. Ross (editor), EMPLOYMENT POLICY AND THE LABOR MARKET (Berkeley: University of California Press, 1965), pp. 115-161.

assigned rank number becomes smaller. As this occurs, the demand for medical technologists increases. Thus, there is some evidence for the proposition that a larger percentage of young and old significantly alter the demand for this allied health manpower category. The demand for medical technologists may be significantly altered by changes in the population composition. The DIFFERNC variable is significant at the 90 percent level and exhibits a negative coefficient. The relationship between quantity and wages is not negative although the estimated coefficient is not statistically significant. The BED, INCOME, RL PRICE, and DUMMY 2 variables were not found to be statistically significant. The TIME coefficient was significant at the 80 percent level which implies that the demand for medical technologists is falling over time.

On the supply side, the coefficients for quantity, DIFFERNC, UNEMPLMT, and TIME were found to be statistically significant at the 95 percent level. As in the previous case, algebraic manipulations result in sign reversals for the exogenous variables on the right hand side of the standard equation form, i.e., as in equation (14). Medical technology supply is significantly responsive to wage changes in the traditionally expected manner. In addition, as DIFFERNC increases, the supply of medical technology effort decreases. Again the coefficient for the unemployment variables yields evidence which supports the additional worker hypothesis. The TIME coefficient indicates that the supply of medical technologists is relatively falling over time.

Dietetic and Nutritional Services Model: Empirical Results

The empirical results for the Dietetic and Nutritional Services Model appear to be reasonable when viewed from a theoretical point of view. Both the supply and demand functions exhibit the traditional slope conditions that would be expected by viewing competitive labor markets. The variables in the demand equation explain 82 percent of the variation in quantity while the variables in the supply equation explain 93 percent of the variation in wages. Both F statistics are significant at the one percent level. The Durbin-Watson statistic for the demand equation does not allow for a conclusive argument against the possibility of first-order negative autocorrelation. A similar interpretation may be made for the supply equation. However, both Durbin-Watson statistics are such that the possibility of positive autocorrelation is firmly rejected. Again, the statistics for individual coefficients allow for only cautious interpretation.

On the demand side, the coefficient for WAGE is statistically significant at the 80 percent level. The sign of the coefficient indicates that as real wages rise the quantity of dieteticians and nutritionalists falls. An interesting addition in the specification for this model was the inclusion of the BED variable and the ENROLL variable. The coefficient for the BED variable is statistically significant at the 95 percent level with a negative sign. This implies that as licensed beds increase, the demand for this allied health manpower category falls. This seemingly improbable result may be the result of the way the influence of

hospitals is entered into the demand equation. If the greater number of licensed hospital beds is due to additions to existing hospitals rather than new hospitals, the demand for dietetic and nutritional services may not be significantly altered. Or, if the enlargement of hospitals overpowers the closures occurring in the industry, this phenomenon would occur. Alternatively, it appears that the pressures to demand these allied health manpower services as a result of greater enrollment (ENROLL) is not statistically significant. Although not statistically significant at a high level, POPLTION, INCOME and RL PRICE exhibit the expected signs. Increases in population and income are expected to increase the demand for dieticians and nutritionists while increases in the relative price of health services generally are expected to decrease such demand.

The estimates of the supply equation indicate that QUANTITY, UNEMPLMT , RL WAGE, and TIME are statistically significant at the 90 percent level. The necessary algebraic manipulations which reverse the signs of the exogenous variables in the supply equation yeild expected results. The positive relationship between the real wage and the quantity supplied is as would be expected from economic theory. The coefficient of the UNEMPLMT variable supports the additional worker hypothesis. The coefficient of the RL WAGE variable indicates that as the wage of food administrators increases relative to the wage of nutritional consultants, the quantity of effort supplied diminishes. In addition, the supply of these services seems to be diminishing as indicated by the TIME coefficient. MIGRTN, DIFFERNC, and DEGREE are not

thought to be statistically significant.

Health Administration Model: Empirical Results

The empirical results for the Health Administration Model seem to be fairly significant. Both the supply and demand functions exhibit the signs expected in viewing a competitive labor market. The variables in the demand equation explain 95 percent of the variation in quantity while the variables in the supply equation explain 85 percent of the variation in wages. Both F statistics are significant at the one percent level. The Durbin-Watson statistic for the supply equation is inconclusive for testing the possibility of positive autocorrelation. Alternatively, the Durbin-Watson statistic for the demand equation implies an inconclusive test for negative autocorrelation. The statistics allow only cautious interpretations.

On the demand side, DIFFERNC, POPLTION and DUMMY 2 are statistically significant at the 90 percent level or better. Large disparities in authorized and filled positions imply decreases in demand. However, as the population increases, the demand for health administrators is expected to rise significantly. The coefficient for the DUMMY 2 variable implies that as the proportion of females increases, i.e., the rank number decreases, there would be a significant increase in the demand for health service administrators. Surprisingly, the BED variable is not statistically significant. A possible explanation for this phenomenon is that the size of hospitals is increasing faster than the number of hospitals. Thus, the number of licensed beds does

not significantly alter the need for administrators.

The results on the supply side indicate that UNEMPLMT, MIGRTN, BED/CAP, and TIME are statistically significant at the 90 percent level. The positive coefficient for unemployment implies that the additional worker phenomenon may be at work here. The positive migration coefficient implies that a net influx of population would bring a greater supply of health administrators. The BED/CAP coefficient is negative. (This variable was originally entered into the supply equation as a means of capturing possible influence of technological efficiency over time. The underlying argument is that as a greater availability of beds per capita is realized individuals who qualify as health administrators may diminish. For example, in rural areas an individual holding an undergraduate business degree might qualify as a health administrator. However, as greater technological efficiency allows a larger number of beds per capita, only individuals with specific training would qualify.) In general, the coefficient for the TIME variable implies that the supply of health administrators is increasing.

Environmental Health Model: Empirical Results.

The empirical results for the Environmental Health Model are satisfactory. The estimates indicate a negative wage-price relationship for demand and a positive relationship for supply. Economic theory would suggest such a result. The variables in the supply equation explain 95 percent of the variation in wages while the variables in the demand equation explain only

75 percent of the variation in quantity. Both F statistics are significant at the one percent level. Both Durbin-Watson statistics can firmly reject the hypothesis dealing with positive autocorrelation. However, an inconclusive test result for negative autocorrelation in the supply equation is exhibited.

On the demand side, WAGE, POPLTION, and DUMMY 2 are statistically significant at the 90 percent level or higher. Increased real wages directly diminish the demand for environmental health manpower. However, as population increases, there should be a significant increase in the demand for this allied health manpower category. The coefficient for DUMMY 2 implies that as the proportion of women increases in California, i.e., the rank number decreases, greater demand for environmental health professionals would be forthcoming. In addition, the DIFFERNC variable is significant at the 80 percent level, implying that as the disparity between authorized and filled positions increases the demand falls.

In the supply side the coefficients for quantity, unemployment and degrees are significant at the 90 percent level. The signs of the exogenous variables are reversed when the results are put into the format of equation (20). Increases in real wage will simultaneously result in greater supply in this allied health manpower market. The coefficient for the unemployment variable lends support to the additional worker hypothesis. The supply of effort diminishes as the number of degrees rises. Again, this unexpected result may be due to the lack of data series, specif-

ically for environmental health graduates. Other variables in the supply equation were found to be statistically insignificant.

Speech Pathology and Audiology Model: Empirical Results

The empirical results for this model are strong for prediction purposes. Ninety-four percent of the variation in quantity is explained by variables in the demand function and 96 percent of the variation in real wages is explained by variables in the supply function. Both F statistics are significant at the one percent level. However, the sign of the WAGE coefficient in the demand curve is not the expected negative as economic theory would have predicted. In this light, the Speech Pathology and Audiology Model may be a viable candidate for a disequilibrium modeling approach as presented below. The Durbin-Watson statistic for the supply equation is such that a firm rejection of the possibility of positive autocorrelation is feasible. The Durbin-Watson statistic for the demand equation is inconclusive for testing the possibility of negative autocorrelation.

The WAGE, DIFFERNC, POPLTION, and RL PRICE variables are statistically significant at the 90 percent level. As the disparity between authorized and filled positions increases, the demand for this allied health manpower category rises. As population increases, the demand falls. The coefficient for the relative price variable implies that demand for speech pathologists and audiologists diminishes when the relative price of health

services increases. The negative coefficient for the DUMMY 1 variable indicates that as California population exhibits a greater proportion of young and old, i.e., the rank number decreases, the demand for this health category increases. From a theoretical point of view, these results are only marginally acceptable.

On the supply side, DIFFERNC, UNEMPLMT, and TIME are statistically significant at the 90 percent level or better. When the estimating equation is put in the function form given in equation (22), the signs of the exogenous variables are reversed. Thus, as DIFFERNC and UNEMPLMT increase, the supply increases. The coefficient for TIME implies that the supply is increasing over time. In general these results seem consistent with economic theory.

ALLIED HEALTH MANPOWER MARKET STRUCTURES: DISEQUILIBRIUM CASE

The modeling and empirical work presented above treat the specified allied health manpower markets as if they were always in equilibrium. This general approach is the traditional methodology stemming from conventional economic theory. As indicated in the beginning of this chapter, many empirical studies in the health area have tended to depart from such traditional supply and demand equilibrium models. Nonprice allocating devices have influenced empirical studies to alter the implications of traditional economic theory.

An alternative approach is to treat each of the allied health care markets as a disequilibrium case. A disequilibrium market is one in which the observed quantity traded in the market is not equal to the ex-ante demand and supply quantities. This phenomenon usually occurs because of the presence of nonprice variables which ration the quantity supplied and hence eliminate equilibrium in the market.[29] Economic theory would support the argument that the allied health manpower markets are in disequilibrium because nonprice variables such as licensing, government educational subsidization, collusive agreements, etc. in-

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[29] Studies on allied health manpower shortages, too numerous to cite here, tend to indicate that the market is in fact in disequilibrium. For a simple discussion of shortages, etc., see Lucy M. Kramer (ed.), PROCEEDINGS AND REPORT OF CONFERENCE ON A HEALTH MANPOWER SIMULATION MODEL (Washington: Division of Manpower Intelligence, 1970), pp. 71-78.

fluence the supply of allied health manpower. The treatment of the allied health manpower markets as disequilibrium cases poses a number of interesting estimation problems which have only recently been recognized.[30]

The nature of the allied health manpower markets in disequilibrium can be made clear by a simple illustrative model. To analyze, we will consider the market for medical technicians. To this purpose, let the model consist of the following equations:

(23) $D_t = \alpha' X_t + U_t$

(24) $S_t = \beta' Z_t + V_t$

(25) $Q_t = \min (D_t, S_t)$

(26) $\Delta P_t = \gamma (D_t - S_t)$

where D_t and S_t are the quantities demanded and supplied, ΔP_t is the change in price, Q_t is the actual quantity observed, X_t and Z_t are vectors of observed variables which influence the demand and supply respectively. The disturbance or shock terms are U_t and V_t and the unknown parameters to be estimated are the vectors α and β and the scaler γ. It is further assumed that D_t, S_t, and ΔP_t are endogenous variables and that U_t and V_t are serially and contemporaneously uncorrelated with zero means and variances σ_u^2 and σ_v^2.

The model specified above may be depicted graphically. Figure 1 represents the disequilibrium market for medical tech-

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[30] Fair, R.C. and Dwight M. Jaffee, "Methods of Estimation for Markets in Disequilibrium," ECONOMETRICA, Vol. 40 (May, 1972), pp. 497-514; Amemiya, Takeshi, "A Note on a Fair and Jaffee Model," ECONOMETRICA, Vol. 42 (July, 1974), pp. 759-62; R.C. Fair and H.H. Kelejian, "Methods of Estimation for Markets in Disequilibrium: A Further Study," ECONOMETRICA, Vol. 42, no. 1 (January, 1974), pp. 177-190; G.S. Maddala and Forest D.Nelson, "Maximum Likelihood Methods for Models of Markets in Disequilibrium," ECONOMETRICA, Vol. 42, No. 6 (November, 1974), pp. 1013-1029.

nicians. Note that the wage structure, i.e., the P's, is measured in real terms.

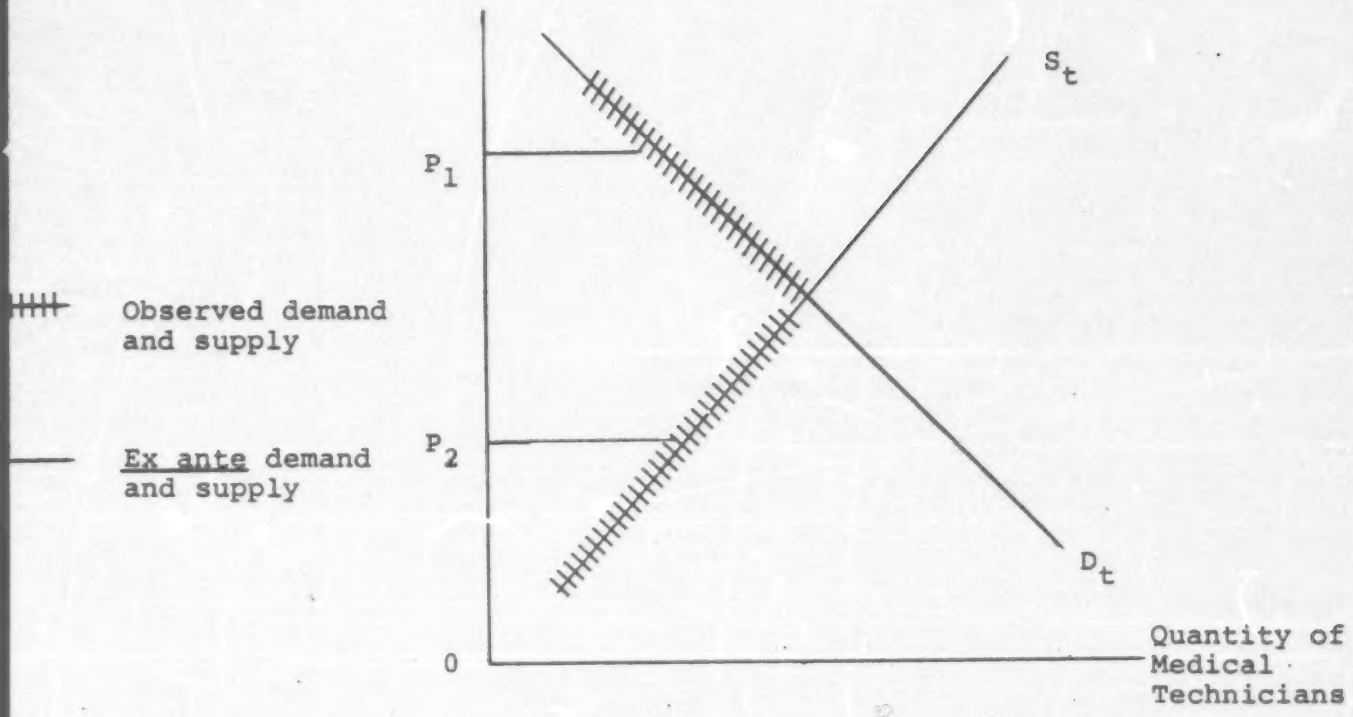

FIGURE 1
Medical Technicians Market
in Disequilibrium

When the price (real wage) of medical technicians is falling the observed quantity is on the demand curve. This is depicted at P_1 in Figure 1. However, when prices are rising, the observed quantity is on the supply function as depicted at P_2. Thus, in periods of excess supply (prices falling), demand will equal the observed quantity while supply will be unobserved. In periods of excess demand (prices rising), supply will equal the observed quantity while demand is unobserved.

The estimation of the model specified in equations (23)

through (26) is possible employing maximum likelihood techniques.[31] By manipulating equations (23) through (26), the following results may be obtained:

$$(27) \qquad Q_t = \alpha' X_t - \gamma^{-1} g_t + U_t,\ g_t \begin{cases} \Delta P_t \text{ if } \Delta P_t \geq 0 \\ 0 \text{ otherwise} \end{cases}$$

and

$$(28) \qquad Q_t = \beta' Z_t - \gamma^{-1} h_t + V_t,\ h_t \begin{cases} -\Delta P_t \text{ if } \Delta P_t < 0 \\ 0 \text{ otherwise} \end{cases}$$

Allowing $\Psi_1 = t|S_t > D_t$ and $\Psi_2 = t|D_t > S_t$ and noting that Ψ_1 (the conditional density of ΔP_{t_2}) given Q_t is $N[\gamma(Q_t - \beta' Z_t), \gamma^2 \sigma_v^2]$ and Ψ_2 (the conditional density of ΔP_{t_2}) given Q_t is $N[\gamma(\alpha' X_t - Q_t), \gamma^2 \sigma^2]$ the likelihood function is given as:

$$(29) \qquad \begin{aligned} \log L = \text{const} &- T \log \gamma - T \log \sigma_u - T \log \sigma_v - \frac{1}{2\sigma_u^2} \cdot \\ &\sum_1 (Q_t - \alpha' X_t)^2 \cdot \frac{1}{2\gamma^2 \sigma_v^2} \sum_1 [\Delta P_t - \gamma(Q_t - \beta' Z_t)]^2 - \frac{1}{2\sigma_v^2} \cdot \\ &\sum_2 (Q_t - \beta' Z_t)^2 - \frac{1}{2\gamma^2 \sigma_u^2} \sum_2 [\Delta P_t + \gamma (Q_t - \alpha' X_t)]^2 \end{aligned}$$

where T is the total number of observations and abbreviation of $\sum_{t \in \Psi_i}$ as $\sum_i$ has occurred. The maximum likelihood estimates are obtained by simultaneously solving:

$$\alpha = (\Sigma X_t X_t')^{-1} (\Sigma X_t Q_t + \frac{1}{\gamma} \sum_2 X_t \Delta P_t)$$

$$\beta = (\Sigma Z_t Z_t')^{-1} (\Sigma Z_t Q_t - \frac{1}{\gamma} \sum_1 Z_t \Delta P_t)$$

$$\sigma_u^2 = \frac{1}{T} \left[\sum_1 (Q_t - \alpha' X_t)^2 + \sum_2 (Q_t + \frac{1}{\gamma} \Delta P_t - \beta' Z_t)^2 \right]$$

$$\sigma_v^2 = \frac{1}{T} \left[\sum_2 (Q_t - \beta' Z_t)^2 + \sum_1 (Q_t - \frac{1}{\gamma} \Delta P_t - \beta' Z_t)^2 \right]$$

$$T\gamma + \frac{1}{\sigma_v^2} \sum_1 (Q_t - \frac{1}{\gamma} \Delta P_t - \beta' Z_t) \Delta P_t - \frac{1}{\sigma_v^2} \sum_2 (Q_t + \frac{1}{\gamma} \Delta P_t - \alpha' X_t) \Delta P_t = 0$$

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[31] Amemiya, Ibid., pp. 650-61.

for α, β, γ, σ_u^2 and σ_v^2 and where Σ without a subscript means that the summation is over all t.

Essentially, the estimation technique is iterative. First, two-stage least squares estimates of α, β, σ_u^2 and σ_v^2 are obtained and substituted into equation (34). Equation (34) is solved for γ (choosing a positive root). Second, the new value of γ is substituted into equations (30) and (31) to solve for α and (β). Third, these values of α and β are employed in equations (32) and (33) to solve for σ_u^2 and σ_v^2. The process continues until the solutions converge.

Table 3 summarizes the results of the initial two-stage least squares estimates for equations (27) and (28). Table 3 also indicates the time period for the data sets employed. The statistical symbols are the same as those used in Table 2 above.

TABLE 3

Initial Two-Stage Least Squares

Estimates for Allied Health

Manpower Markets in Disequilibrium

Physical Therapy Disequilibrium Estimation 1956-1973		Occupational Therapy Disequilibrium Estimation 1956-1975	
1 Quantity TSLS	2 Quantity TSLS	1 Quantity TSLS	2 Quantity TSLS
WAGE	WAGE	WAGE	WAGE
-0.005256	0.003964	0.000505	-0.000210
-1.428421	1.872819	0.141906	-0.278519
DIFFERNC	DIFFERNC	DIFFERNC	DIFFERNC
-0.011582	-0.012620	-0.016856	-0.016688
-2.226354	-3.263918	-6.126449	-10.416238
POPLTION	DEGREE	POPLTION	RL WAGE
0.636786	-0.011627	0.108734	1.134566
2.650214	-4.232602	0.380861	2.623370
INCOME	UNEMPLMT	INCOME	DEGREE
0.013107	0.102406	-0.017186	-0.024767
0.802456	3.207877	-0.586594	-8.633487
RL PRICE	MIGRTN	RL PRICE	UNEMPLMT
3.409638	-0.000387	0.050850	0.047775
0.854420	-0.775083	0.017438	3.416068
DUMMY 1	RL WAGE	TIME	MIGRTN
0.004507	-4.431364	0.027156	-0.000422
1.546245	-1.051200	0.106382	-1.684899
DUMMY 2	TIME	DUMMY 1	TIME
0.002115	0.083310	0.001456	0.096325
0.737741	1.732159	1.254161	6.129170
TIME	CONSTANT	DUMMY 2	CONSTANT
-0.286489	2.318085	0.005900	-0.263246
-1.572595	0.855116	0.865148	-0.525387
CONSTANT	R-SQ./SE	CONSTANT	R-SQ./SE
-8.393026	0.814710	-0.575020	0.931811
-1.733252	0.087316	-0.109333	0.038609
R-SQ./SE	DW(D)/F	R-SQ./SE	DW(D)/F
0.726927	1.245302	0.819785	2.700019
0.106000	12.306404	0.062767	32.234806
DW(D)/F		DW(D)/F	
2.461799		2.898352	
6.989553		10.097836	

TABLE 3

(CONTINUED)

Diet. and Nutr. Services Disequilibrium Estimation 1956-1975		Medical Technology Disequilibrium Estimation 1958-1975	
1 Quantity TSLS	2 Quantity TSLS	1 Quantity TSLS	2 Quantity TSLS
WAGE	WAGE	WAGE	WAGE
-0.003448	0.001242	0.000219	0.004140
-1.494226	0.974388	0.126861	2.775578
DIFFERNC	DIFFERNC	DIFFERNC	DIFFERNC
-0.021411	0.010599	-0.012450	-0.018938
-0.825432	0.632443	-2.352553	-4.277553
BED	DEGREE	BED	RL WAGE
-0.001630	-0.032644	-0.000454	-0.614068
-2.014300	-3.454068	-0.643970	-0.530561
ENROLL	UNEMPLMT	POPLTION	DEGREE
0.105635	0.081361	0.147422	-0.001858
0.634761	3.081508	1.311136	-1.136794
POPLTION	MIGRTN	INCOME	UNEMPLMT
0.341018	-0.000422	-0.008778	0.084767
1.028068	-0.879077	-0.997449	2.613539
INCOME	RL WAGE	RL PRICE M	MIGRTN
0.009010	-2.001868	-2.015840	-0.000670
0.551528	-1.124129	-0.893262	-1.316740
RL PRICE	TIME	DUMMY 1	TIME
-1.423930	0.084217	-0.000882	-0.046980
-0.512849	1.838943	-0.900814	-0.899302
DUMMY 1	CONSTANT	DUMMY 2	CONSTANT
-0.000986	1.872716	-0.000396	-0.717804
-0.653415	1.361828	-0.120562	-0.513116
DUMMY 2	R-SQ./SE	TIME	R-SQ./SE
-0.005471	0.767518	0.019405	0.720083
-1.152679	0.071744	0.203390	0.074282
TIME	DW(D)/F	CONSTANT	DW(D)/F
-0.108188	2.495755	0.635545	2.426748
-0.493533	8.546060	0.247957	7.614967
CONSTANT		R-SQ./SE	
-1.305251		0.821160	
-0.204989		0.059375	
R-SQ./SE		DW(D)/F	
0.799932		1.965655	
0.066555		10.183197	
DW(D)/F			
1.679345			
7.397268			

TABLE 3

(CONTINUED)

Environmental Health
Disequilibrium Estimation
1957-1975

1 Quantity	2 Quantity
TSLS	TSLS
WAGE	WAGE
-0.012384	0.004453
-1.291253	2.651753
DIFFERNC	DIFFERNC
-0.036660	-0.003746
-1.018065	-0.175539
POPLTION	RL WAGE
0.773524	-0.001833
1.599217	-0.992950
INCOME	UNEMPLMT
-0.002732	0.097395
-0.105378	2.005939
RL PRICE	MIGRTN
8.192879	0.001269
0.721840	1.599274
TIME	TIME
-0.162904	-0.002104
-0.516572	-0.078154
DUMMY 1	DEGREE
0.001475	-0.000079
0.488357	-0.522270
DUMMY 2	CONSTANT
-0.011194	-2.784488
-1.053643	-2.930455
CONSTANT	R-SQ./SE
-9.923072	0.503261
-0.874253	0.121142
R-SW./SE	DW(D)/F
-0.091732	2.012569
0.179593	3.460453
DW(D)/F	
1.834805	
0.821449	

Health Administration
Disequilibrium Estimation
1956-1975

1 Quantity	2 Quantity
TSLS	TSLS
WAGE	WAGE
-0.000200	-0.000033
-0.298005	-0.077232
DIFFERNC	DIFFERNC
-0.033507	-0.021465
-1.054775	-0.935367
INCOME	DEGREE
-0.007144	0.000007
-1.796777	0.099262
RL PRICE	UNEMPLMT
-3.201496	0.022602
-2.037338	0.984290
BED	MIGRTN
-0.002368	0.000633
-3.641215	1.718430
POPLTION	BED/CAP
0.126332	-57.829228
2.372901	-6.107430
TIME	TIME
0.062306	0.045530
1.511865	1.743433
DUMMY 1	CONSTANT
0.000333	1.106275
0.622235	2.133631
DUMMY 2	R-SQ./SE
0.000665	0.864801
1.037192	0.062950
CONSTANT	DW(D)/F
2.575052	1.747732
1.985314	17.448219
R-SQ./SE	
0.945845	
0.039841	
DW(D)/F	
2.417106	
35.930813	

TABLE 3

(CONTINUED)

Speech Pathology & Audiology
Disequilibrium Estimation
1956-1971

1 Quantity TSLS	2 Quantity TSLS
WAGE	WAGE
0.005677	0.001215
0.918473	0.599323
DIFFERNC	DIFFERNC
0.001641	-0.017623
0.039223	-0.771754
ENROLL	DEGREE
0.050335	-0.043876
0.084816	-0.621775
POPLTION	MIGRTN
1.449886	-0.000018
0.822280	-0.025790
INCOME	UNEMPLMT
0.107858	-0.074779
1.075918	-1.697420
RL PRICE	TIME
0.949009	0.043548
0.131508	0.944247
DUMMY 1	CONSTANT
-0.001700	-0.196004
-0.377221	-0.124954
DUMMY 2	R-SQ./SE
0.007129	0.828757
1.051346	0.104990
TIME	DW(D)/F
-1.192642	1.788989
-0.911216	12.292538
CONSTANT	
-26.299309	
-0.820481	
R-SQ./SE	
0.815243	
0.109054	
DW(D)/F	
1.782280	
7.863904	

Although empirical interpretation may be given to the results in Table 3, these initial estimates used in the iterative process described above do not warrant such an effort. Table 4 summarizes the results of the maximum likelihood estimation procedure, coefficients, variances, γ and the number of iterations are reported.

TABLE 4

Occupational Therapy

Disequilibrium Estimates

Final Iteration*

Demand Variables	Coefficients α
DIFFERNC	-12.648440
POPLTION	-3641.4331
INCOME	-340.82922
RL PRICE	-20064.469
TIME	3355.3753
DUMMY 1	1.3025238
DUMMY 2	6.6896165
CONSTANT	72319.090

σ_u^2 =56418.1

Supply Variables	Coefficients β
DIFFERNC	-.61622830
RL WAGE	-1419.6539
DEGREE	-2.6959770
UNEMPLMT	-10.458483
MIGRTN	-.34213381E-01
TIME	10.819106
CONSTANT	1577.9957

σ_v^2 =1156.36

γ =218.732

*Solution converges on 6th iteration.

TABLE 4

(Continued)

Physical Therapy

Disequilibrium Estimates

Final Iteration*

Demand Variables	Coefficients α
DIFFERNC	-2.8743139
POPLTION	-863.41145
INCOME	-85.142389
RL PRICE	-14474.534
DUMMY 1	2.3423013
DUMMY 2	5.0189376
TIME	947.82513
CONSTANT	25082.312

σ_U^2 =18658.5

Supply Variables	Coefficients β
DIFFERNC	.40640313
DEGREE	-1.9980982
UNEMPLMT	-21.455306
MIGRTN	.10448341
RL WAGE	-7790.0141
TIME	26.682632
CONSTANT	6807.9895

σ_V^2 =4702.97

γ =219.170

*Solution converges on 7th iteration.

TABLE 4
(Continued)
Dietetic and Nutritional Services

Disequilibrium Estimates

Final Iteration*

Demand Variables	Coefficients α
DIFFERNC	-359.18834
BED	-9.4329536
ENROLL	3263.4769
POPLTION	-7486.8114
INCOME	-340.21838
RL PRICE	-54554.460
DUMMY 1	6.6711642
DUMMY 2	1.1267783
TIME	5147.2098
CONSTANT	152218.06

σ_u^2 =152016.

Supply Variables	Coefficients β
DIFFERNC	-3.7922843
DEGREE	3.1320036
UNEMPLMT	-25.439623
MIGRTN	-.87417470
RL WAGE	-6054.8625
TIME	-25.730349
CONSTANT	5403.5529

σ_v^2 =4705.03

γ =87.0751

*Solution converges on 7th iteration.

TABLE 4

(Continued)

Medical Technology

Disequilibrium Estimates

Final Iteration*

Demand Variables	Coefficients α
DIFFERNC	-24.691440
BED	-2.0500087
POPLTION	-1100.0373
INCOME	-82.625515
RL PRICE	-16756.694
DUMMY 1	-2.7416863
DUMMY 2	-12.495378
TIME	1085.5784
CONSTANT	30573.695

σ_u^2 =27046.3

Supply Variables	Coefficients β
DIFFERNC	-2.8627017
RL WAGE	-2895.6210
DEGREE	-.17415812
UNEMPLMT	-16.924582
MIGRTN	-.91612591
TIME	-30.171817
CONSTANT	2444.0945

σ_v^2 =2002.99

γ =213.561

*Solution converges on 7th iteration.

TABLE 4

(Continued)

Environmental Health

Disequilibrium Estimates

Final Iteration*

Demand Variables	Coefficients α
DIFFERNC	-15.704151
POPLTION	-1123.1089
INCOME	-95.030136
RL PRICE	-15330.604
TIME	1107.6505
DUMMY 1	-.16264761
DUMMY 2	-4.0481885
CONSTANT	30770.687

σ_{U^2} =29150.2

Supply Variables	Coefficients β
DIFFERNC	.58933119
RL WAGE	-.36577288
UNEMPLMT	-23.490908
MIGRTN	-.34081613
TIME	6.2622257
DEGREE	-.49179776E-01
CONSTANT	332.04246

σ_{V^2} =306.683

γ =343.925

*Solution converges on 5th iteration.

TABLE 4

(Continued)

Health Administration

Disequilibrium Estimates

Final Iteration *

Demand Variables	Coefficients α
DIFFERNC	156.14217
INCOME	-42.779715
RL PRICE	-16373.198
BED	-3.1530148
POPLTION	-581.57034
TIME	687.93301
DUMMY 1	.13532768
DUMMY 2	-1.9656494
CONSTANT	22241.460

σ_u^2 =29267.7

Supply Vairables	Coefficients β
DIFFERNC	13.465611
DEGREE	-.10387550
UNEMPLMT	-32.741349
MIGRTN	-.54038391
BED/CAP	-9241.8680
TIME	23.542406
CONSTANT	527.59445

σ_v^2 =674.370

γ =628.575

*Solution converges on 6th iteration.

TABLE 4

(Continued)

Speech Pathology and Audiology

Disequilibrium Estimates

Final Iteration*

Demand Variables	Coefficients α
DIFFERNC	76.207059
ENROLL	2579.9401
POPLTION	-13186.116
INCOME	-958.34707
RL PRICE	-49721.338
DUMMY 1	6.4070267
DUMMY 2	-17.563086
TIME	10271.624
CONSTANT	228293.50

σ_u^2 =148128

Supply Variables	Coefficients β
DIFFERNC	1.7932419
DEGREE	-14.899611
MIGRTN	-.20795976
UNEMPLMT	-8.0817372
TIME	.17740049E-01
CONSTANT	149.02761

σ_v^2 =91.6184

γ =427.139

*Solution converges on 6th iteration.

ALLIED HEALTH MANPOWER MARKET STRUCTURES: SIMULATION AND PROJECTIONS WITH THE EQUILIBRIUM CASE

The market structures specified in equations (9) through (22) for which the two-stage least squares (TSLS) estimates were given in Table 2 were employed to project allied health manpower in the seven specific categories. As in most economic simulations, there are underlying assumptions of those variables which are common to all models and the assumptions which are aimed at a particular market.

First, the projected population variable, POPLTION, employs the estimates given in Table 2 of the Modified Ratio Method above. While State of California Department of Finance projections might have been employed, there is no persuasive reason for choosing one of the Department's series over another. Thus, internalized projections are used. Second, the series for California personal income is a modification of income projections made by the UCLA Econometric Model in their June, 1976, Quarterly Forecast Update Conference. The projected unemployment rates also make use of the UCLA forecasts but are corrected for use as the "old series." Third, the projections for California net migration assume no significant decline in net migration in the 1969-1975 time period compared to the previous two decades; it sees to have generally stabilized. Both the UCLA Econometric Model and the work presented here assume a constant relationship between California and the rest of the United States. Thus, there is no

convincing economic reason to assume increasing net migration in search of relative economic opportunities. Fourth, the variables DUMMY 1 and DUMMY 2 take on their 1970 rank values. Finally, the TIME variable is allowed to increase cardinally.

The final assumptions employed which are specific to particular allied health manpower markets are summarized in Table 5. These assumptions are based on exogenous information, the variation in the data and economic judgement. The reader is cautioned that the symbols in each model may represent a different data series. In the projections which follow, it is clear that a different set of assumptions could substantially alter the predicted results.

Before presenting the projections, it may be useful to discuss the rationale behind the assumptions presented in Table 5. In general, the values used for the DIFFERNC variable are dependent upon the variablility in the data series. For example, since no systematic variation is evident in the DIFFERNC variable for Physical Therapy, the average over the entire data time period has been employed. However, since the data for the Occupational Therapy DIFFERNC variable indicate a structural change between the most recent periods and previous ones, the information from the more recent period has been used.

The relative price variable, RL PRICE, has been fairly invariant from 1973 to present. (In order to capture this phenomenon, 1975 levels were employed.) Use of the RL WAGE variable

TABLE 5

PROJECTION ASSUMPTIONS

FOR 1976-1980

Occupational Therapy

DIFFERNC: Average difference from 1967-1972 assumed.
RL PRICE: No change from 1975 level assumed.
RL WAGE: Average of 1968-1973 assumed.
DEGREE: Changes based on 4.7% increase observed in 1973-1974 time period.

Physical Therapy

DIFFERNC: Average difference from 1956-1975 assumed.
RL PRICE: No change from 1975 level assumed.
DEGREE: Average increase of 5.48% from 1970-1975 assumed.
RL WAGE: Average of 1970-1975 assumed.

Medical Technology

DIFFERNC: Average difference over 1970-1975 assumed.
BED: 1975 level assumed.
RL PRICE: 1975 level assumed.
RL WAGE: Adjusted by average increase of 0.8% over 1956-1975 time period.
DEGREE: Adjusted by average increase of 6.08% over the 1970-1975 time period.

Dietetic and Nutritional Services

DIFFERNC: Average difference over 1958-1975 assumed.
BED: 1975 level assumed.
ENROLL: 1975 level assumed
RL PRICE: 1975 level assumed
RL WAGE: Average level over 1972-1975 time period assumed.
DEGREE: Adjusted for 6.36% average increase over 1970-1975.

TABLE 5

(Continued)

Health Administration

DIFFERNC:	Average difference over 1956-1975 assumed.
RL PRICE:	1975 level assumed
BED:	1975 level assumed
DEGREE:	1975 level assumed.
BED/CAP:	1975 level assumed.

Environmental Health

DIFFERNC:	Average difference over 1957-1975 assumed.
RL PRICE:	1975 level assumed.
RL WAGE:	1975 level assumed.
DEGREE:	1975 level assumed.

Speech Pathology and Audiology

DIFFERNC:	1971 level assumed.
ENROLL	Adjusted by increase of 6% from 1974-1975.
RL PRICE:	1975 level assumed.
DEGREE:	Adjusted by 6% average increase from 1969-1971 from American Speech and Hearing Association data.

differed depending on its variability in each market; in some cases variability was negligible while in others adjustments were necessary. The DEGREE variable was adjusted when extraneous information was available in some quantities, e.g., information from the American Speech and Hearing Association allowed a 6% adjustment. In general, the overriding philosophy was to use the status quo unless extraneous and convincing evidence was uncovered.

Table 6 summarizes the results of the projections for the various allied health manpower categories assuming that each market is in equilibrium. In addition to the expected values produced by our model, predictions one standard error below and one standard error above the expected value are also provided. It must be noted that the projections given in the occupational therapy category are based on the endogenous variables and statistically significant, i.e., 10% level, exogenous variables. The initial simulated projections resulted in explosive predictive values. This problem may be in part due to the estimated negative relationship between wage and quantity of effort in the supply equation (see Table 2).

Since the "below" category is computed one standard error less than the expected while the "above" category is one standard error above the expected, a confidence interval type interpretation is possible. As a loose interpretation, it may be argued that about two-thirds of the time one would expect the true value to fall within the interval determined by the values

given in the below and above category.[32] Relatively speaking, if the interval is narrow (reflecting a smaller standard error), there is greater credibility given the expected value. Table 7 summarizes the relative sizes of the reported intervals. As Table 7 indicates, there is some concern for the usefulness of the empirical results, especially in the physical therapy category.

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[32]Of course, this interpretation must be altered to consider finite sample size. See Johnston, op. cit., pp. 400-408

Table 6

ALLIED HEALTH MANPOWER

PROJECTIONS 1976-1980

EQUILIBRIUM CASE

CATEGORY	1976	1977	1978	1979	1980
Medical Technology					
Expected	10278	10709	11131	11534	11922
Below	10079	10517	10937	11518	11731
Above	10476	10914	11334	11735	12127
Occupational Therapy**					
Expected	2391	2644	2909	3169	3467
Below	2237	2490	2755	3030	3319
Above	2546	2799	3064	3339	3629
Dietetic and Nutritional Services					
Expected	3289*	3609	3950	4422	4882
Below	3022	3342	3683	4155	4615
Above	3556	3876	4217	4689	5149
Physical Therapy					
Expected	2030	2256	2522	3012	3485
Below	1695	1921	2187	3150	
Above	2365	2591	2857	3347	3820
Health Administration					
Expected	15095	15387	15747	16163	16579
Below	14138	14429	14789	15205	15621
Above	16051	16342	16702	17118	17534
Environmental Health					
Expected	1340	1381	1421	1457	1496
Below	1308	1349	1389	1426	1463
Above	1372	1414	1452	1489	1522
Speech Pathology and Audiology					
Expected	1314	1785	2355	2834	3249
Below	1168	1639	2210	2688	3103
Above	1459	1930	2501	2980	3395

*As of May, 1976, the California Dietetic Association reports 3275

*Results based on simulation of endogenous variables and statistically significant exogenous variables.

Table 7

RELATIVE INTERVAL SIZE

1980: EQUILIBRIUM CASE

CATEGORY	Relative Interval Size
Medical Technology	3.32%
Occupational Therapy	8.94%
Dietetic and Nutritional Services	10.93%
Physical Therapy	19.22%
Health Administration	11.53%
Environmental Health	3.94%
Speech Pathology and Audiology	8.98%

ALLIED HEALTH MANPOWER MARKET STRUCTURES: SIMULATION AND PROJECTIONS WITH THE DISEQUILIBRIUM CASE

Each of the specified allied health manpower markets was also estimated under the assumption that the particular market in question was in disequilibrium. In each case, the underlying assumptions regarding the behavior of the economic forces at hand are identical with those reported for the equilibrium case above. Table 8 summarizes the results of disequilibrium market projections.

As Table 8 indicates, when the allied health manpower markets are treated as disequilibrium cases, three of the categories projected peak in 1976 with a gradually diminished market thereafter. If these results are taken literally, a case might be made for the argument that the medical technology, occupational therapy and environmental health markets are countercyclical, since the economic variables in the simulation are based on an improving economy. An alternative explanation is, of course, that these three markets do not fit a disequilibrium modeling approach.

Table 8

ALLIED HEALTH MANPOWER

PROJECTIONS 1976-1980

DISEQUILIBRIUM CASE

CATEGORY	1976	1977	1978	1979	1980
Medical Technology					
Expected	10972	10420	9768	9004	8098
Below	10136	9584	8933	8169	7263
Above	11807	10279	10604	9839	8933
Occupation Therapy					
Expected	3046	2867	2680	2493	2301
Below	2894	2714	2528	2340	2148
Above	3199	3020	2833	2646	2453
Dietetic and Nutritional Services					
Expected	2984	3203	3441	3782	4112
Below	2780	2999	3237	3577	3908
Above	3188	3407	3645	3986	4316
Physical Therapy					
Expected	1569	1578	1613	1806	1979
Below	1234	1244	1278	1471	1645
Above	1901	1913	1948	2140	2314
Health Administration					
Expected	15051	15444	15880	16343	16806
Below	14181	14574	15009	15473	15936
Above	15922	16315	16750	17214	17677
Environmental Health					
Expected	1335	1303	1253	1190	1114
Below	1186	1152	1104	1041	965
Above	1485	1450	1402	1340	1263
Speech Pathology and Audiology					
Expected	1972	2189	2383	2567	2748
Below	1750	1968	2166	2345	2527
Above	2193	2411	2609	2788	2969

Table 9 summarizes the relative sizes of the reported intervals. As these results indicate the interval under a disequilibrium modeling approach is consistently larger than in the equilibrium case.[33] These results clearly suggest that for predictive purposes the disequilibrium approach is inferior to the equilibrium one. Perhaps the use of more refind and rich data or nonprice allocating variables would improve the empirical results of the disequilibrium approach.

Table 9

RELATIVE INTERVAL SIZE

1980: DISEQUILIBRIUM CASE

CATEGORY	RELATIVE INTERVAL SIZE
Medical Technology	20.62%
Occupational Therapy	13.25%
Dietetic and Nutritional Services	9.92%
Physical Therapy	33.80%
Health Administration	10.35%
Environmental Health	26.75%
Speech Pathology and Audiology	16.08%

EMPIRICAL SUMMARY

Table 10 summarizes the various allied health manpower projections made under the basic ratio approach, the usage modified ratio approach, the equilibrium case, and the disequilibrium case for 1980. As Table 10 indicates, the equilibrium case tends to estimate greater allied health manpower requirements in most

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[33] See Table 7 above for comparison

categories. In any case, ratio modification or economic projections generally yield larger 1980 needs.

Table 10

SUMMARY OF DIFFERENT

PROJECTION METHODS FOR

1980

CATEGORY	BASIC RATIO	MODIFIED RATIO	EQUI-LIBRIUM	DISEQUI-LIBRIUM
Medical Technology	10290	11991	11922	8098
Occupational Therapy	2271	2898	3467	2301
Dietetic and Nutritional Services	3265	3745	4882	4112
Physical Therapy	1853	2106	3485	1979
Health Administration	14984	14984	16579	16806
Environmental Health	1426	1591	1496	1114
Speech Pathology and Audiology	1948	2966	3249	2748

SUMMARY

The objective of this study has been to develop an economic approach to the forecasting of allied health manpower in markets in the State of California. The health manpower categories considered included:

medical technology

occupational therapy

dietetic and nutritional services

physical therapy

health administration

environmental health

speech pathology and audiology

These forecasts are quite useful in curriculum planning, faculty staffing, and career development. In addition, projection of manpower needs in these seven categories provides some indication of the general characteristics of the allied health manpower markets which exist in California.

MARKET HETEROGENEITY

An overriding theme that has become evident as a result of the empirical work is that these allied health manpower markets are heterogeneous. For example, variables which may be significant in one market were found not to be significant in another. There is strong reason to believe that none of these markets can be treated jointly, at least from the economist's point of view.

Even in cases where skill substitutability was thought to

be significant,[1] attempts to empirically confirm this phenomenon met with failure. The relative WAGE variable is one means of addressing the substitutability issue.[2] In all cases where it was used it was found to be statistically insignificant. Thus, this study would tend to support the argument that future inquiry into these allied health manpower categories should treat each market separately.

DATA NEEDS

The most significant issue which has become apparent as a result of this study is the need for data of high quality. Like all empirical studies, the conclusions which could be drawn are constrained by the quality of the data used. As an illustration, the quantity variable used in this study was an index of the filled positions of hospitals in California. While these positions seem to be a significant part of the market, they can only serve as approximations of the quantities traded there. Thus, there is an apparent need to collect complete market data on all allied health manpower categories.

On the supply side, there is little information regarding individuals entering and leaving the markets. In order to project allied health manpower needs, the following series would be useful:

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[1]See Summary of Econometric Modeling Questionnaire Section, p. 105 above.

[2]See Samuel Bowles, PLANNING EDUCATIONAL SYSTEMS FOR ECONOMIC GROWTH (Cambridge: Harvard University Press, 1969), pp.50-63.

total number of graduates by type of skill

net migration by type of skill

net inflow from nonactive individuals in California possessing these skills

licensure data by skill

job mobility patterns by skill

promotion patterns within skills

This information would certainly improve the quality of empirical results from the supply point of view.

The demand side would also profit from improved data. The series which would be most helpful include:

use of each manpower category by age, sex, income and regional area

relative prices of the use of the particular skill compared with those of other medical services and other forms of consumption

a measure of the rate of technological innovations occurring in the production of health services provided by these skills

This information would substantially improve what can be done empirically with respect to the allied health manpower categories under consideration.

WHICH TYPE OF MODELING?

The present study projects allied health manpower needs using: (1) the basic ratio approach; (2) the modified ratio approach; (3) an econometric approach with markets in equilibrium; and (4) an econometric approach with markets in disequilibrium. The type of

methodology which is most useful depends to a great extent upon the data required. In general, data needs increase from the basic ratio approach to the disequilibrium approach. In addition, staff requirements to implement these methodologies increase in the same fashion.

While the basic and modified ratio approaches are easily programmed for staff use,[3] the general conclusion of this study is that the econometric approach with markets in equilibrium is the most viable. The results of the equilibrium approach account for the simultaneous nature of supply and demand without the severe data requirements of a disequilibrium methodology. However, given the types of data noted in the previous section, a substantial argument might be made for treating these allied health manpower markets as disequilibrium cases.

FUTURE RESEARCH

This economic study of California allied health manpower needs suggests areas for future research. Besides initial efforts to collect basic data, these efforts should consider:

the impact of licensure requirements on California allied health manpower

the nature of competition in California allied health manpower markets

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[3]See FORTRAN Program

the production of health services: the role of allied health manpower

the impact of technological change in the production of health services: the case of allied health manpower in California

the impact of changes in national health policy with respect to methods of finance and/or delivery on California allied health manpower

While the suggested studies deal with fairly narrow subjects, it is felt that the present study could serve as a basis from which analysis would proceed.

POLICY IMPLICATIONS

Major changes in national health policy can impact the analysis of allied health manpower markets. If national health insurance becomes a reality it can influence both the delivery of health services and the ability to purchase health care. The models developed in this report provide a baseline for further analysis of national health policy impacts. However, the broad proposals contained in proposed legislation must be translated more explicitly before the models developed can be modified.

Recent developments in health care policy which have encouraged the development of health maintenance organizations (HMOs) can be investigated directly with these models because the basic theoretical assumption employed was that the demand for allied health manpower services is derived from the production function for health services. To the extent that positive incentives for

the formation of HMOs influence the production function, the impacts on allied health manpower markets can be measured. However, since little information has been developed regarding the production of health care services, very little additional research can be done at this time. For example, until the directional impact of HMO formation on technical change in health care and its labor market efforts is known, it is impossible to proceed further. New technology may increase demand for allied health manpower while other changes such as automated laboratory equipment will reduce the demand.

CONCLUSION

Better health care is a goal of all Americans. In order to achieve this objective within reasonable time limits and with scarce physical and financial resources, it will be necessary to capture the economic benefits of labor specialization. As traditional health care providers begin to recognize the value to society achieved through delegating some aspects of health services to non-physician personnel, the need for closer analysis of allied health manpower markets becomes essential. This report is an attempt to address this need. However, it should be recognized that the present effort has been handicapped by the need for adequate data. In the future more adequate data must be generated to provide better economic analysis of these markets and allow the development of appropriate policy recommendations.

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